THE CHEMISTRY, DISPERSION, AND TRANSPORT OF AIR POLLUTANTS EMITTED FROM FOSSIL FUEL POWER PLANTS IN CALIFORNIA

Plume Tracer (SF_6) Measurement
and Analyses

FINAL REPORT

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ABSTRACT

Nine extensive tracer field studies were conducted during September, October, and November, 1974, to determine the transport and dispersion associated with each of three large power plants along the coast in California. Sulfur hexafluoride (SF_6), an inert, non-toxic gaseous tracer, was injected into one of the main stacks at each of the three power plants, and concentrations were monitored downwind by each of three different methods: one-hour averaged samples at fixed ground-level locations, ground-level traverses, and airborne traverses.

In each of the three tests conducted in the Moss Landing-Salinas area, the afternoon plume trajectories from Moss Landing were in a southeast direction following the Salinas Valley. In each of the six tests conducted in the Los Angeles area, the afternoon plume trajectories from Long Beach were northeast toward Fullerton and Pomona, and then eastward toward San Bernardino. Integration of the ground-level traverse data accounted for the rate of tracer released within a factor of two in all cases. The maximum one-hour averaged equivalent SO_2 and NO_2 concentrations, calculated from the tracer data, were found to be 0.13 ppm and 0.12 ppm, respectively; these peak readings did not exceed the current California air quality standards.

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Roger Sperling (of Environmental Measurements, Incorporated) helped us obtain ground-level tracer traverse data during the Moss Landing studies.

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PERSONNEL

The following persons participated in the Moss Landing-Salinas area field studies:

1. Mr. James D. Bruchie
2. Dr. Peter J. Drivas
3. Mr. Charles H. Hales
4. Mr. John L. Horn, Jr.
5. Dr. Fredrick H. Shair

The following persons participated in the Los Angeles area field studies:

1. Dr. Peter J. Drivas
2. Mr. Charles H. Hales
3. Mr. John L. Horn, Jr.
4. Mr. Brian K. Lamb
5. Dr. Fredrick H. Shair

Mr. Greg Gibson also helped during the preliminary testing of the automatic sequential air samplers.

DEFINITION OF UNITS

ppm (parts per million) = parts specie per 10^6 parts of air, by volume

ppt (parts per trillion) = parts specie per 10^{12} parts of air, by volume

$= 10^{-6}$ ppm

For the Moss Landing-Salinas area studies, all times are given as Pacific Daylight Savings Time (PDT).

For the Los Angeles area studies, all times are given as Pacific Standard Time (PST).

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1. Introduction

1.1 Objectives of Field Program

An extensive field program, sponsored by the State of California Air Resources Board, was conducted during September, October, and November, 1974 to determine the impact of three large power plants on the air quality of their surrounding areas. Other participants in the program will be listed below. The work performed by personnel at the California Institute of Technology involved the use of an inert chemical tracer, sulfur hexafluoride, to determine the transport and dispersion associated with each of the three power plant plumes.

The main objectives of the tracer study were as follows:

(1) To provide fundamental information concerning plume transport and dispersion over complex terrain in urban coastal regions.

(2) To characterize, by comparison with stack SO_2 and NO concentrations, the concentrations of SO_2 and NO_2 downwind attributable only to power plant plumes.

(3) To provide data which can be used to determine the applicability of various atmospheric dispersion models, and the importance of meteorological parameters in these models, in the prediction of pollutant concentrations.

(4) To provide a non-reactive "baseline" needed to determine the extent of particulate sulfate formation in a plume from the oxidation of SO_2, and the extent of NO_2 formation from the oxidation of NO.

The achievement of objective (1) is discussed in detail in section 3 of this report (covering the Moss Landing studies), and in section 4 (covering the Los Angeles area tests). The usefulness of the tracer data in achieving the latter three objectives is discussed in sections 5 and 6.

1.2 Program Participants and Responsibilities

(1) California Institute of Technology (Caltech) - Release of SF_6 tracer at power plants, establishment of ground-level sampling system, and analysis of all SF_6 samples.

(2) Meteorology Research, Inc. (MRI) - Aircraft sampling of various pollutants in plume, aerial SF_6 sampling, pibal releases from two locations, and interpretation of meteorological information.

(3) Rockwell International - Establishment of ground-level sampling and analysis system for SO_2, and ground-level particulate sampling.

(4) California Department of Health, Air and Industrial Hygiene Laboratory (AIHL) - Chemical analysis of particulate samples.

(5) Environmental Measurements, Inc. (EMI) - Mobile tracking of plume by measuring excess SO_2 and NO_X.

(6) Systems Applications, Inc. (SAI) - Interpretation of all data to form a predictive model.

1.3 Other Tracer Studies

A large-scale tracer test, also using SF_6, was conducted recently by Systems, Science, and Software (S^3) from the Ormond Beach power plant in Ventura County, California (Giroux et al., 1973). As in the present study, aerial SF_6 samples were taken and ground-level instantaneous traverses were made. However, the majority of the ground-level samples were averaged over a 4-hour period, in contrast to the one-hour averaged samples in the present study. In addition to following time-dependent concentration levels more closely, the one-hour averaged samples provide a direct comparison with the California standards for SO_2 and NO_2.

Another large-scale tracer test was recently conducted throughout the Los Angeles region by Metronics involving a fluorescent particle technique (Vaughan and Stankunas, 1974). These tests generally involved ground-level area source releases; however, several releases were made from one power plant stack in Long Beach. Regretfully, no data on the amount of tracer particles in the stack was given; consequently those results cannot be quantitatively compared with the present work, nor can they be used to predict equivalent SO_2 or NO_x concentrations.

Of particular interest for the Los Angeles Basin tests is the one tracer release made by Drivas and Shair (1974). In this study, 33.5 kilograms (74 lbs.) of SF_6 were released from ground level from the central region of the city of Anaheim and traced to five neighboring communities downwind including Palm Springs, which at 124 km away was the furthest location tested. A preliminary analysis of the data indicated that the cities of Riverside and Palm Springs possibly lie in a direct path of the pollutant transport from Anaheim. Thus, a ground-level release from Anaheim near the mouth of the Santa Ana Canyon was transported through the canyon directly to Riverside. This result should be compared with the results from the Long Beach power plants; that is, any part of the Long Beach plume which reaches central Anaheim is also expected to be transported through the Santa Ana Canyon when the normal prevailing wind conditions occur.

2. Experimental

2.1 Sampling System

One-hour averaged ground-level tracer data were taken with a number of automatic sequential sampling units (Developmental Sciences, Inc., City of Industry, California). Each sampling unit consisted of twelve motor-driven 30-cc syringes, which each sampled sequentially for a one-hour duration; the total sampling time thus covered a 12-hour interval. Eighteen of the sampling units were used in the Moss Landing tests and nineteen of the units were used for the Los Angeles Basin tests. A 24-hour timer, which was set the day before a test, was used to activate the sampling units.

Figure 1 shows one of the sampling units in a typical location in the Moss Landing area. In general, the sampling units were located on the roofs of low buildings or trailers. Figure 2 shows another of the sampling units at Moss Landing being adjusted the day before a test. Laboratory experiments had previously demonstrated that the reproducibility and accuracy of the sampling units were quite good: within ±1% if analyzed immediately; within ±4% if analyzed after 20 hours in an outdoor environment. Appendix A-1 contains the details of the laboratory experiments on a sequential sampling unit.

Airplane samples were taken by MRI with a screw-driven sampler which pulled back one 30-cc syringe at a constant rate for a time period of typically one minute. The airplane samples were thus averaged over the length of the traverses made by the MRI aircraft. The airborne SF_6 data, along with the SO_2 and NO_x data (collected in the MRI airplane), were very useful in determining the vertical structure of the plumes. The airborne SF_6 data are tabulated in Appendix A-7.

In addition, ground-level traverses were obtained by manual syringe sampling from an automobile. Approximately 10-sec average syringe samples were taken manually at various points along a ground route in an automobile. These manual samples proved quite useful in outlining the concentration distribution along a path perpendicular to the plume centerline. The SF_6 traverse data are tabulated in Appendix A-8.

2.2 SF_6 Analysis System

Analysis of all syringe samples was accomplished through the use of four electron-capture gas chromatographs. The operating details of these chromatographs are described elsewhere (Drivas, 1974). Integration of the SF_6 peaks from each of the four chromatographs was accomplished by an electronic digital integrator (Spectra-Physics, Santa Clara, California). The chromatograph-integrator combination proved quite efficient--one person could analyze up to 80 syringe samples per hour. In addition, the chromatograph-integrator combination took up little space and was fairly portable. For the Moss Landing tests the four chromatographs and the integrator were set up in a motel room in Salinas, as shown in Figure 3.

Calibration of the four chromatographs was accomplished by means of a well-mixed exponential dilution system. Typical calibration curves for the four chromatographs (designated by Y1, Y2, Z1, and Z2) are shown in Figures 8 through 11. For each chromatograph, the linear dynamic range was approximately 10^4, and the minimum detection limit (based on three times the peak-to-peak noise level) was one part SF_6 in 10^{12} parts of air or one part per trillion (ppt).

It should be noted that these instruments were calibrated over the entire range of interest, as compared to the technique often used which involves just one point. Calibrations were made before the Moss Landing tests, after the Moss Landing tests, and after the Los Angeles area tests. As indicated in Appendix A-2, the calibration of the detectors changed somewhat with usage. This change is thought to be due to slight contamination of the detector foil by other components present in the air samples. It is believed that any particular point could be recalculated to be within ±5% of the true value (see Appendix A-2). To correct all of the data in this manner did not appear to be worth the effort in view of the minimal influence that this correction would have upon the results. Consequently, the data points tabulated in Appendices A-4, A-7, and A-8, are within at least ±30% of the true values, with most of the data accurate to ±15%.

2.3 Stack Injection System

The system for releasing SF_6 into the stack consisted of six large cylinders (each containing 100 lbs of SF_6) which were manifolded together and controlled by one pressure regulator (Matheson Model 8H-590). A large-volume flowmeter (F. & P. Co. Model B6-35-10/27) was attached after the regulator to monitor the flow at a constant rate. From the flowmeter the tracer gas was conducted through a length of 1/2-inch copper or stainless steel tubing to a convenient stack sampling port. The length of tubing used ranged from 20 to 75 feet. At the Moss Landing power plant the stack connection was made in the main duct before the air pre-heater; at the Alamitos plant in Long Beach the stack connection was made after the air pre-heater. At the Haynes plant in Long Beach the tracer was released inside the center of the stack itself. Since SF_6 is stable to 600°C (Saltzman et al., 1966), none of the tracer decomposed as a result of being injected into ducts containing gases having maximum temperatures of around 300°C.

Figures 4 and 5 show the stack injection system at the Moss Landing power plant, including a close-up of the regulator-flowmeter assembly. Figure 6 shows the release system at the Alamitos plant in Long Beach. To insure accuracy in the measurement of the amount of tracer released, the gas bottles were weighed before and after each run, as shown in Figure 7. The total amount of SF_6 released was also within ±2% of that determined by the calibrated rotameter. As shown in Figure 6, the rotameter was continuously monitored by a Caltech person during each test; in each case the flow rate was observed to be constant over the seven-hour release period.

3. <u>Moss Landing Power Plant Tests</u>

Three SF_6 releases were made on consecutive days in September, 1974 from the Pacific Gas and Electric Moss Landing Power Plant. The plant site, adjacent to the Pacific Ocean in Moss Landing, California, is indicated in Figure 12. Eighteen sequential sampler units, also shown in Figure 12, were located mainly in the Salinas Valley area at distances up to 44 km from the power plant. The eighteen sampling locations and their distances from the power plant are listed in Table 1.

The release was made from Unit 7 of the Moss Landing Power Plant; this unit has a maximum power rating of 750 megawatts and exhausts from a 152 m (500 ft.) stack. Typically about 540 pounds of SF_6 were released during each test. A summary of the three tests made from this unit is given in Table 2. During each test the tracer flow rate was constant over the 7-hour test duration. The release rates of SF_6 were determined by weighing the gas bottles before and after each run. The stack gas SF_6 concentration was, however, an estimated quantity based on the standard calculation of the

TABLE 1

Distances from Pacific Gas and Electric Moss Landing Power Plant to Location of Sequential Air Samplers

Sampler Location Number	Sampler Location	Distance in Miles	Distance in Kilometers
1	Construction Trailer	7.9	12.7
2	School House (Garin Co.)	8.1	13.1
3	Unidynamics	9.1	14.7
4	Fire Station	9.9	16.0
5	Anderson Ranch	10.2	16.4
6	Fort Ord	10.5	16.9
7	Merril Farms	12.0	19.3
8	Duroc's Hogs	12.1	19.5
9	Motel 6	12.7	20.4
10	USDA	13.1	21.1
11	Spreckels	14.5	23.3
12	Firestone	15.7	25.2
13	Pumphouse	15.9	25.6
14	Youth Science Center	17.9	28.7
15	Yoder Bros.	20.1	32.3
16	Verticare	20.3	32.6
17	Hollister	20.7	33.3
18	Gonzales	27.2	43.7

TABLE 2

Summary of Moss Landing Power Plant Tests

Moss Landing Test No.	Date	Fuel	Time of Release (PDT)	SF_6 Release Rate (g/sec)	Total SF_6 Released (lb)	SF_6 Stack * Concentration (ppm)
1	9/10/74	Oil	10 am-5 pm	9.74	541	2.34
2	9/11/74	Oil	10 am-5 pm	9.76	542	2.54
3	9/12/74	Gas	10 am-5 pm	9.79	544	2.70

* Expressed on a wet basis (see Appendix A-3).

stack exhaust gas flow rate (Goodley, 1975). Details of this calculation are given in Appendix A-3. An estimate of the accuracy of the exhaust flow rate calculation can be obtained by comparing the measured SO_2 concentration in the exhaust with that predicted from the known sulfur content of the fuel; such calculations performed by Goodley (1975) indicate that the calculations are accurate to ±2%.

Moss Landing Test No. 1 (9/10/74)

A summary of the sequential sampler data from Test No. 1 is given in Figure 13 by means of one-hour average bar graphs at each location. The SF_6 concentration scale is linear from 0 to 450 ppt, and the time scale ranges from 8:00 a.m. to 8:00 p.m. (PDT). A close-up showing the detail of an individual bar graph is shown in Figure 59. The SF_6 raw data (one-hour averages) for all nine tests (Moss Landing and Long Beach) are tabulated in Appendix A-4.

Airborne SF_6 measurements, along with temperature, SO_2, and NO_X data taken with the MRI aircraft, were very useful in determining the vertical structure of the plume and in interpreting the ground-level SF_6 data. The airborne SF_6 data are tabulated in Appendix A-7. A summary of temperature inversion readings and effective stack heights for the three Moss Landing tests is presented in Table 3.

As can be seen from Figure 13, very low concentrations of tracer were observed at ground level for Moss Landing Test No. 1. During this test the effective stack height, determined from the MRI airborne measurements, was about 370 m (1200 ft); the base of the temperature inversion was determined to be at about 150 m (500 ft). It should be noted from Table 3 that the effective stack height was about the same level as the top of the temperature

TABLE 3

MRI Airborne Measurements for the Moss Landing Tests

Date	Source of Data	Time(PDT)	Base of Temperature Inversion(ft)	Top of Temperature Inversion(ft)	Effective Stack Height(ft)
9/10/74	Spiral near plant	End 11:32	600	1500	-
	Spiral near plant	End 12:51	400	1300	1800
	Spiral near plant	End 14:07	300	1400	1300
	Spiral near Salinas	End 16:55	600	1800	-
	Traverses-1 mile	11:39-12:42	-	-	1400
	Traverses-1 mile	14:09-14:33	-	-	1200
	Traverses-5 miles	14:48-15:31	-	-	1200
9/11/74	Spiral near plant	End 11:21	300	1900	-
	Spiral near plant	End 14:14	800	2000	-
	Traverses-1 mile	11:26-11:51	-	-	1500
9/12/74	Spiral near Salinas	End 14:32	2100	2500	-
	Spiral near plant	End 16:59	2100	2700	1000
	Traverses-1 mile	16:08-16:42	-	-	1100

Data estimated accurate to ±100 ft.

Note that all heights are relative to sea level.

inversion; thus, any pollutants transported to ground level had to pass through a fairly strong, approximately 220 m (700 ft) thick inversion layer. The low ground-level concentration of tracer is thought to be due to the inversion layer simply preventing the elevated plume from reaching the ground.

Figures 14 and 15 show three-hour average concentration isopleths, expressed as fraction of stack concentration, for the intervals of 11:00 a.m. to 2:00 p.m. and 2:00 to 5:00 p.m., respectively. For the first time period (11:00 a.m. to 2:00 p.m.) no significant tracer concentration was recorded at ground level.

In the isopleth graphs such as Figure 15, the solid lines indicate contours well supported by the data sampling network. The dashed lines indicate approximate contours either outside the sampling network or at some distance from any sampling point.

Moss Landing Test No. 2 (9/11/74)

A summary of the sequential sampler data from Test No. 2 is given in Figure 16 by means of one-hour average bar graphs at each location. As in Figure 13, the SF_6 concentration scale is linear from 0 to 450 ppt, and the time scale ranges from 8:00 a.m. to 8:00 p.m. (PDT). Ground-level concentrations of SF_6 were found to be quite high in a fairly well-defined region. The plume shape is defined clearly in the three-hour average isopleth graphs shown in Figures 17 and 18.

During the afternoon, the temperature inversion base was measured to be at a height of about 240 m (800 ft) above ground. The effective stack height was not determined in the afternoon, however, during the two other test days, it was of the order 300-370 m (1000-1200 ft). It is probable that during this test the plume was trapped just below the inversion layer, resulting in relatively high concentrations downwind. Another possible explanation is that the plume was trapped within the inversion layer, transported downwind with relatively little mixing, and finally transported to ground level.

Figure 19 shows the results of a ground-level traverse with an automobile; as can be seen, the plume centerline corresponds quite well to that recorded by the sequential samplers. Two different traverses were made along paths approximately 2 km apart, as shown in Figure 20. The traverse data are tabulated in Appendix A-8. If the similar traverse data are superimposed, as shown in Figure 21, an average wind direction of $327^{\circ} \pm 1.6^{\circ}$ can be calculated. Pibal data from the Salinas airport at 3:00 p.m. resulted in wind directions, changing slightly with height, of 326-332°.

<u>Moss Landing Test No. 3 (9/12/74)</u>

A summary of the sequential sampler data from Test No. 3 is given in Figure 22; the SF_6 concentration scale is 0 to 450 ppt and the time scale ranges from 8:00 a.m. to 8:00 p.m. (PDT). During the time of interest the effective stack height (see Table 3) was about 300 m (1000 ft) above ground level; the temperature inversion height was about 640 m (2100 ft). As indicated in Figure 22, the ground-level concentrations are lower than those observed during Test No. 2. Three-hour averaged concentration isopleths are shown in Figures 23 and 24. In Figure 23, the apparent bimodal distribution is probably due to shifting morning winds. Of interest is the fact that in Figure 24, the plume centerline was along the eastern edge of the Salinas Valley, while in Figure 18 (Test No. 2), the plume centerline was approximately at the center of the valley.

4. Long Beach Power Plant Tests

A total of six SF_6 releases were conducted in October and November, 1974 from two power plants adjacent to each other in Long Beach, California. Three tests (labeled Long Beach Tests No. 1, 2, and 3) were conducted from the City of Los Angeles Department of Water and Power Haynes Steam Plant, and three tests (labeled Long Beach Tests No. 4, 5, and 6) were conducted from the Southern California Edison Alamitos Generating Station. The two release points were less than 400 m apart, and are indicated as a single source on the Los Angeles Basin map in Figure 25. Twenty-two ground-level sampling locations at distances up to 86 km from the power plants are also shown in Figure 25. Only nineteen of the sampling stations were used in any test; the detailed information on the actual stations used in each test is provided in Appendix A-4. The twenty-two sampling locations and their distances from the power plants in Long Beach are listed in Table 4.

The first three releases (Long Beach Tests No. 1, 2, and 3) were made from Unit 6 of the Haynes plant; this unit has a maximum power rating of 350 megawatts and exhausts from a 76 m (250 ft) stack. The last three releases (Long Beach Tests No. 4, 5, and 6) were made from Unit 6 of the Edison plant; this unit has a maximum power rating of 480 megawatts and exhausts from a 67 m (220 ft) stack. In all six tests the power plants used oil as fuel. A summary of all six tests is given in Table 5. As in Table 2, the stack gas SF_6 concentration is a calculated quantity; the details of the calculations are given in Appendix A-3. Between 270 and 500 pounds of SF_6 were released during each of the tests conducted in Los Angeles; however, during each test, the tracer flow rate was constant over the 7-hour test duration.

TABLE 4

Distances from Haynes and Alamitos Power Plants

in Long Beach to Location of Sequential Air Samplers

Sample Location Number	Sample Location	Distance in Miles	Distance in Kilometers
1	Long Beach APCD	6.9	11.2
2	Anaheim F.S. #2	9.6	15.4
3	Medical Center	10.5	16.9
4	Fullerton F.S. #2	10.8	17.4
5	Whittier APCD	11.9	19.2
6	Lynwood APCD	13.3	21.5
7	Orange F.S. #3	14.8	23.7
8	Fullerton F.S. #5	14.9	24.0
9	Anaheim F.S. #8	18.1	29.2
10	Lennox APCD	19.7	31.8
11	Central L.A. APCD	21.5	34.6
12	Baldwin Park	23.3	37.5
13	Diamond Bar F.S.	23.3	37.5
14	Featherly Park	23.5	37.8
15	Walnut F.S.	24.0	38.7
16	Azusa APCD	27.6	44.3
17	Pomona APCD	29.0	46.6
18	Chino APCD	29.5	47.5
19	Corona F.S.	32.5	52.3
20	Riverside F.S. #8	36.8	59.2
21	Riverside Central F.S.	44.6	71.8
22	San Bernardino APCD	53.3	85.8

TABLE 5

Summary of Long Beach Power Plant Tests

Long Beach Test No.	Date	Time of Release (PST)	SF_6 Release Rate (g/sec)	Total SF_6 Released (lb)	SF_6 Stack* Concentration (ppm)
1	10/01/74	9 am-4 pm	5.14	286	2.48
2	10/11/74	10 am-5 pm	4.83	269	2.20
3	10/17/74	10 am-5 pm	5.15	286	2.30
4	10/25/74	10 am-5 pm	8.97	498	2.63
5	10/30/74	10 am-5 pm	6.50	361	2.00
6	11/07/74	10 am-5 pm	7.74	430	2.27

*Expressed on a wet basis (see Appendix A-3).

Long Beach Test No. 1 (10/1/74)

A summary of the sequential sampler data from Test No. 1 is given in Figure 26 by means of one-hour averaged bar graphs at each location. The SF_6 concentration scale is linear from 0 to 250 ppt, and the time scale on the graphs ranges from 8:00 a.m. to 8:00 p.m. (PST). The SF_6 raw data (one-hour averages) for all nine tests (Moss Landing and Long Beach) are tabulated in Appendix A-4. As in the Moss Landing tests, airborne measurements of SF_6, along with temperature, SO_2 and NO_X data, were taken with the MRI aircraft. The airborne SF_6 data are tabulated in Appendix A-7. A summary of temperature inversion readings and effective stack heights for the six Long Beach tests is presented in Table 6. During this test, the inversion base was relatively high at about 610 m (2000 ft); the effective stack height was about 240 m (800 ft).

Figures 27 and 28 show three-hour averaged concentration isopleths, expressed as fraction of stack concentration. As in other isopleth graphs, the solid lines indicate contours well supported by the data sampling network; the dashed lines indicate approximate contours either outside the sampling network or at some distance from any sampling point. As can be seen, the predominant flow pattern was northeast toward Fullerton and Pomona, and then eastward toward San Bernardino. No significant tracer concentrations were recorded in the Santa Ana Canyon.

In this test and in some of the other tests, low levels of SF_6 concentration (of the order 10 ppt) were recorded in some locations before the tracer was released. This observation is probably due to local sources of contamination, for example leaks of SF_6 from high-voltage circuit breakers. Since the tracer concentrations were of the order 100 ppt, the low levels of contamination encountered did not prove to be a problem in defining the

TABLE 6

MRI Airborne Measurements for the Los Angeles Tests

Date	Source of Data	Time(PST)	Base of Temperature Inversion(ft)	Top of Temperature Inversion(ft)	Effective Stack Height(ft)
10/1/74	Spiral near plant	End 13:01	1800	2400	800
	Spiral-Los Alamitos	End 14:28	2100	2400	800
	Spiral-Fullerton	End 15:36	2200	2400	-
	Spiral-S.A. Canyon	End 15:55	1900	2500	-
	Traverses-1 mile	13:09-13:21	-	-	1000(1)
	Traverses-4 miles	13:44-14:12	-	-	1000(1)
10/11/74	Spiral-Los Alamitos	End 13:18	2900	3500	-
	Spiral-S.A. Canyon	End 16:01	2900	3500	-
	Spiral-Fullerton	End 16:17	3200	3600	-
	Spiral-Los Alamitos	End 17:02	3000	3600	-
	Spiral-Riverside	End 17:29	3200	3400	-
10/17/74	Spiral-Los Alamitos	End 14:37	None(2)	-	600
	Spiral-Fullerton	End 15:50	None(2)	-	600
	Spiral-El Monte	End 16:24	None(2)	-	1000
	Spiral-Los Alamitos	End 17:21	100	1000	700
	Traverses-1 mile	13:58-14:05	-	-	1000(1)
10/25/74	Spiral-Los Alamitos	End 12:15	None	-	800
	Spiral-Fullerton	End 15:57	None	-	-
	Spiral-S.A. Canyon	End 16:50	None	-	-
	Traverses-1 mile	12:05-13:02	-	-	1000(1)
	Traverses-3 miles	13:17-13:41	-	-	1000(1)
10/30/74	Spiral-Los Alamitos	End 12:43	None	-	-
	Spiral-Fullerton	End 15:54	None	-	-
	Traverses-1 mile	12:49-13:17	-	-	1000(1)
11/7/74	Spiral-Los Alamitos	End 13:45	None	-	700
	Spiral-Fullerton	End 15:57	None	-	-

(1) Lowest traverse altitude flown.

(2) No data above 2500 ft.

Note that all heights are relative to sea level.

plume trajectories.

Long Beach Test No. 2 (10/11/74)

A summary of the sequential sampler data from Test No. 2 is given in Figure 29 by means of one-hour averaged bar graphs at each location. The SF_6 concentration scale is linear from 0 to 125 ppt, and the time scale ranges from 8:00 a.m. to 8:00 p.m. (PST). Figures 30 and 31 show three-hour averaged concentration isopleths. A ground-level traverse by automobile is shown in Figure 32; the traverse data are tabulated in Appendix A-8. From Figures 31 and 32, the main flow was clearly similar to Long Beach Test No. 1. Mobile plume tracing by Environmental Measurements, Inc. resulted in a similar plume trajectory (EMI, 1975). During this test the inversion base was very high, approximately 950 m (3100 ft); the effective stack height could not be determined accurately. During this one day, relatively high contamination levels of SF_6 were recorded at the Corona station; these anomalous data points are discussed in Appendix A-9.

Long Beach Test No. 3 (10/17/74)

A summary of the sequential sampler data from Test No. 3 is given in Figure 33; the SF_6 scale is linear from 0 to 125 ppt and the time scale ranges from 8:00 a.m. to 8:00 p.m. (PST). Figures 34 and 35 show three-hour averaged concentration isopleths. A ground-level traverse by automobile is shown in Figure 36. Although concentrations were spread out over a fairly large area, the main flow was similar to that observed in the first two tests. No significant tracer concentrations were recorded in the Santa Ana Canyon. The EMI measurements indicated a similar plume trajectory. During this test the effective stack height (see Table 6) was about 180 m (600 ft); there was no temperature inversion during this test.

Long Beach Test No. 4 (10/25/74)

A summary of the sequential sampler data from Test No. 4 is given in Figure 37; the SF_6 scale is linear from 0 to 200 ppt and the time scale ranges from 8:00 a.m. to 8:00 p.m. (PST). Figures 38 and 39 show three-hour averaged concentration isopleths. Two ground-level traverses are shown in Figure 40 which delineate the plume boundaries quite clearly. In this test the power plant plume was very clearly defined as traveling in a narrow region northeast toward Fullerton and Pomona. During this day the effective stack height was about 240 m (800 ft); again, there was no temperature inversion during this study.

Long Beach Test No. 5 (10/30/74)

A summary of the sequential sampler data for Test No. 5 is presented in Figure 41; the SF_6 scale is linear from 0 to 350 ppt and the time scale ranges from 9:00 a.m. to 9:00 p.m. (PST). Figures 42 and 43 show three-hour averaged concentration isopleths. Two ground-level traverses are shown in Figure 44, which, as in Figure 40, define the power plant plume very clearly. The tracer results (after 2:00 p.m.) are again very similar to the tests conducted on previous days. The EMI measurements again indicated a similar plume trajectory. During this test the effective stack height was not determined accurately; again there was no temperature inversion during this study.

Long Beach Test No. 6 (11/7/74)

A summary of the sequential sampler data for Test No. 6 is presented in Figure 45; the SF_6 scale is linear from 0 to 900 ppt and the time scale ranges from 9:00 a.m. to 9:00 p.m. (PST). Figures 46 and 47 show three-hour averaged concentration isopleths. Because numerous ground-level traverses were made, and the wind was apparently shifting around considerably, one-hour averaged concentration isopleths are also presented; Figures 48-53 show isopleths for each hour between 11:00 a.m. and 5:00 p.m.

On this day a number of ground-level traverses were made in an attempt to follow the transient behavior of the plume. Figures 54-56 show the plume behavior during the afternoon, shifting slowly from the normal northeast trajectory to a more easterly trajectory and also decreasing in magnitude. A traverse made along Highway 405, approximately 2.5 km from the release point, showed no significant SF_6 concentration. Thus, the plume touched down somewhere between 2.5 km and the Anaheim station at 15 km distance. All the ground-level traverse data are tabulated in Appendix A-8.

It should be noted that this was the only day of the six tests that a definite plume was detected in the Santa Ana Canyon. However, as shown in Figures 52 and 53, the main tracer concentration impact was still recorded in the northeast toward Fullerton and Pomona. During this test, the effective stack height (see Table 6) was about 210 m (700 ft); there was no temperature inversion. During the morning two extremely high SF_6 points were recorded at stations 2 and 3; these anomalous data points are discussed in Appendix A-9.

5. Discussion of Results

5.1 Integration of Traverse Data

The ground-level traverse data taken with an automobile (Figures 19, 32, 36, 40, 44, 54, 55, and 56) proved very useful in determining wind direction and defining an instantaneous plume boundary. Integration of the curves can yield two more important points of information:

(1) A calculation of the average flux of tracer passing through the traverse area provides a direct comparison with the amount of tracer released at the stack. This tracer mass balance, even though based upon simplifying assumptions, is of interest in order to provide a check on the consistency of the data; the mass balance is described below in section 5.1.1.

(2) The traverse data provide an experimental determination of the crosswind standard deviation of the plume, normally defined as σ_y. These calculated values, described in section 5.1.2, can be used to determine an effective Pasquill-Gifford stability class and to check the applicability of the Gaussian plume model.

5.1.1. Conservation of Tracer Gas

Consider a plane perpendicular to the wind direction. The steady-state flux of a tracer through this plane can be defined in general as,

$$Q = \int_0^\infty \int_{-\infty}^\infty u(z)c(y,z)dydz$$

where c is the concentration of tracer and u is the wind velocity. Consider the much simpler case of: (1) a constant wind velocity with height, $u = \bar{u}$; (2) well-mixed concentrations in the vertical direction; and (3) no transport above an inversion height, z = H. The flux equation then simplifies to:

$$Q = \bar{u}H \int_{-\infty}^{\infty} c(y)dy \qquad (1)$$

Thus, integration of the traverse data, combined with values of an average wind velocity and an inversion height, should yield a flux close to that released at the stack.

The ground-level traverse data from the appropriate figure (listed in Table 7) were integrated numerically using Simpson's rule and equation (1). The values of $\bar{u}$ and H used in the calculations are listed in Table 7. These values were determined from preliminary data on wind speed versus height provided by MRI; the value H was chosen as either the temperature inversion base or the altitude at which the wind changed direction. The resulting fluxes, calculated using equation (1), are compared to the actual release fluxes in Table 7.

Considering the number of simplifying assumptions, agreement is quite good, with all of the calculated values being within a factor of two of the SF_6 release rates. Of interest is the fact that the Moss Landing Test No. 2 traverse resulted in a calculated flux higher by a factor of two than the actual release flux. If an inversion height of 120 m is used for the Moss Landing Test No. 2 traverse, the result is almost perfect agreement with the release flux. An interesting point is that the MRI aircraft, flying at approximately the same time and downwind distance as the traverse, could not locate a plume at altitudes higher than 200 m. It should be noted that in all cases, a simplified flux calculation accounted for the rate of tracer released within a factor of two.

5.1.2. Calculation of Crosswind Standard Deviation (σ_y)

From the traverse data, the standard deviation (σ_y) of each curve can

TABLE 7

Comparison of SF_6 Release Rates ($Q_{release}$) with Calculated Fluxes from Traverse Data (Q_{calc})

Test	Traverse Figure No.	$\bar{u}$,m/sec	H,m	$Q_{release}$ (g/sec)	Q_{calc} (g/sec)	$Q_{calc}/Q_{release}$
Moss Landing Test No. 2	19	10.0	240	9.76	18.79	1.9
Long Beach Test No. 2	32	2.5	550	4.83	5.30	1.1
Long Beach Test No. 3	36	3.0	400	5.15	6.61	1.3
Long Beach Test No. 4	40	4.5	450	8.97	7.20	0.8
Long Beach Test No. 5	44	5.5	550	6.50	7.33	1.1
Long Beach Test No. 6	54	4.5	500	7.74	10.01	1.3
Long Beach Test No. 6	55	6.0	500	7.74	6.14	0.8
Long Beach Test No. 6	56	5.0	800	7.74	4.69	0.6

easily be calculated. The standard deviation is a basic statistical parameter, defined by the equation (Bevington, 1969):

$$\sigma_y^2 = \frac{\int_{-\infty}^{\infty} y^2\ c(y)dy}{\int_{-\infty}^{\infty} c(y)dy} - \left[\frac{\int_{-\infty}^{\infty} y\ c(y)dy}{\int_{-\infty}^{\infty} c(y)dy}\right]^2 \qquad (2)$$

The ground-level traverse data from the appropriate figure (listed in Table 8) were numerically integrated using Simpson's rule and equation (2). The resulting values for the crosswind standard deviation (σ_y) are given in Table 8. The σ_y values are expected to be accurate representations of the plume width, since as shown in the previous section the mass balance could account for essentially all the tracer released. These values of σ_y were used to determine values of the corresponding Pasquill-Gifford stability class from the curves in Turner (1970). The stability classes determined from the calculated values of σ_y were close but not identical to those predicted from wind speed and insolation values (Turner, 1970); these values are presented in Table 8.

Of interest is the fact that the Long Beach traverses, except for Long Beach Test No. 3, resulted in approximately the same σ_y value (~ 800m), which corresponds to the neutral stability class D. The same σ_y value was found for the one complete Moss Landing traverse. This fact is surprising in view of the enhanced dispersion expected from the highly urban surface roughness in Los Angeles. The results are not conclusive, but the fact remains that most of the traverses in Los Angeles were quite similar in terms of crosswind dispersion to the one complete Moss Landing traverse. These results indicate the degree of uncertainty to be expected when Gaussian diffusion models are used in the absence of data concerning a specific locale.

TABLE 8

Crosswind Standard Deviations (σ_y) from Traverse Data

Test	Traverse Figure No.	σ_y (meters)	Pasquill-Gifford Stability Class from calculated σ_y	Predicted Stability Class from Turner (1970)
Moss Landing Test No. 2	19	1040	D	C-D
Long Beach Test No. 2*	32	844	D	B-C
Long Beach Test No. 3	36	2460	A	B-C
Long Beach Test No. 4	40	769	D	B-C
Long Beach Test No. 5	44	864	D	C-D
Long Beach Test No. 6	54	1220	C	B-C
Long Beach Test No. 6	55	534	E	C-D
Long Beach Test No. 6	56	637	E	C-D

*Two distinct peaks were observed in this traverse, a large main peak and a secondary smaller peak; the calculation was based only on the large main peak.

5.2 Gaussian Plume Model Prediction for Moss Landing Test No. 2

Of all the nine tracer tests conducted, the Moss Landing Test No. 2 results for the afternoon of 9/11/74 most closely resembled a Gaussian plume model, as can be seen in Figure 18. To model this behavior, the standard Gaussian plume model approach (Turner, 1970) was used, with an inversion height of 244 m (800 ft) as measured by the MRI aircraft. Stability class D was used to approximate the traverse data result in Table 8. Details of the calculation are given in Appendix A-5.

Concentration isopleths, expressed as fraction of stack concentration, are given in Figure 57, which can be compared directly to Figure 18. The comparison between Figure 57 and 18 is quite striking; the isopleths are very similar except for the fact that the experimental concentrations were higher than the predicted ones by a factor of about two. Similarly, in a previous report on the Moss Landing Power Plant (Cayot, 1971), experimental NO_2 concentrations downwind were found, on the average, to be about three times higher than those predicted by a similar Gaussian model. It is possible that meteorological conditions in the Salinas Valley, caused by heating of the mountain slopes on either side, may result in an effective inversion height lower than normal. This feature would explain the high concentrations recorded in Moss Landing Test No. 2, and is consistent with the flux conservation calculation discussed in section 5.1.1.

6. Equivalent SO_2 and NO_2 Concentrations

6.1 Equivalent Concentration Isopleths

Since the SF_6 injected into the stack is diluted along with the other stack gases by atmospheric turbulence, any SF_6 concentrations measured at ground-level downwind can be converted to equivalent ground-level pollutant concentrations associated with the particular stack. The pollutant concentration at ground level is related to that at the exit of the stack by the following expression,

$$(C_{pt})_{ground} = (C_{pt})_{stack} \times \frac{(C_{SF_6})_{ground}}{(C_{SF_6})_{stack}} \tag{3}$$

where C_{pt} is the pollutant concentration and C_{SF_6} is the SF_6 concentration. Since all the concentration isopleths in sections 3 and 4 are expressed in terms of the ratio $[(C_{SF_6})_{ground}/(C_{SF_6})_{stack}]$, the isopleths can be used to determine ground-level pollutant concentrations by simply multiplying this ratio by the stack concentration of the pollutant of interest. Two important assumptions in this ratio method are that either the pollutant is <u>non-reacting</u> (as taken in the case of SO_2) or <u>reacts completely</u> to form a stable compound (as taken in the case of NO forming NO_2). The validity of these assumptions influences the validity of the equivalent pollutant isopleths.

In order to simplify the isopleth comparison, total emissions of SO_2 and NO from the Moss Landing plant and the Haynes-Edison complex in Long Beach were assumed to result from one equivalent stack (this corresponds to assuming that the emissions from all stacks are thoroughly mixed). Calculations were made for the Moss Landing power plant using the source strengths measured by Goodley (1975). Calculations were made for the Haynes-Edison complex in Long Beach using the source strengths estimated from power plant operational data by Rockwell (Richards, 1975). Table 9 shows the source strengths and the resulting effective stack concentrations, assuming that the total emissions at each location are emitted from one stack.

The source strengths in Table 9 can be compared to the yearly-averaged source strengths of 60 tons/day SO_2 and 55 tons/day NO_X for Moss Landing (Cayot, 1971) and the yearly-averaged source strengths for the two Long Beach plants of 92 tons/day SO_2 (TRW, 1974) and 63 tons/day NO_X(Bartz et al., 1974). The effective stack concentrations in Table 9 are artificial numbers obtained by dividing the total source strengths (expressed as flow rates) by the stack gas flow rate of the one stack from which the tracer was released (see Appendix A-3). This was done in order to have a convenient method of calculating equivalent SO_2 and NO_2 concentrations resulting from all stacks by use of equation (3). This procedure is valid at distances downwind when the stacks can be considered as equivalent to a single source.

The concentration isopleths in sections 3 and 4 can thus be converted to equivalent SO_2 and NO_2 concentrations by simply multiplying the isopleth values by the values given in Table 9, assuming that the SO_2 is non-reacting and all the NO reacts to form NO_2. These limiting cases yield the maximum possible concentration of SO_2 and NO_2. Using this technique, the equivalent SO_2 concentrations associated with Long Beach Test No. 6, as shown in Figure 58, were obtained from the isopleth curves in Figure 46.

6.2 Peak One-Hour Averaged Equivalent Concentrations

The California hourly-averaged standards, established by the Air Resources Board, are 0.5 ppm for SO_2 and 0.25 ppm for NO_2. In order to compare with these standards, the peak one-hour averaged SF_6 readings for

TABLE 9

Total Source Strengths and Effective Stack Concentrations

Test	Total SO_2 tons/day	Total NO_x tons/day*	Total SO_2 ppm**	Total NO_x ppm**
Moss Landing Test No. 1	54.2	36.6	320.	300.
Moss Landing Test No. 2	60.0	29.5	380.	260.
Moss Landing Test No. 3	0.4	21.1	2.4	200.
Long Beach Test No. 1	102.	71.8	1200.	1200.
Long Beach Test No. 2	105.	65.3	1200.	1000.
Long Beach Test No. 3	111.	74.6	1200.	1100.
Long Beach Test No. 4	108.	76.2	770.	760.
Long Beach Test No. 5	114.	69.8	850.	730.
Long Beach Test No. 6	127	74.4	900.	740.

*Expressed as NO_2.

**Expressed on a wet basis (see Appendix A-3).

each test were converted to equivalent SO_2 and NO_2 concentrations using equation (3) and Table 9. The results are shown in Table 10, <u>assuming that the SO_2 is non-reacting and all the NO reacts to form NO_2</u>.

Neither the SO_2 standard nor the NO_2 standard was exceeded on any of the tests. The highest equivalent SO_2 concentration recorded was 0.13 ppm at Location No. 2 (western Anaheim) in Long Beach Test No. 5; this peak reading was 26% of the 0.5 ppm SO_2 one-hour standard. The highest equivalent NO_2 concentration recorded was 0.12 ppm at Location No. 4 (Fullerton) in Long Beach Test No. 1; this peak reading was 48% of the 0.25 ppm NO_2 one-hour standard.

An important point is the assumption of 100% reaction of the NO to form NO_2. The chemical kinetics of this reaction are discussed in Appendix A-6. Since the travel time to the locations of highest concentration was approximately 60 minutes, calculations were made to determine the amount of NO_2 which could have been formed during that time. Calculations were made using two simple models (discussed in detail in Appendix A-6).

In the first model, two major assumptions were made. First, a parcel of air moving within the plume is diluted exponentially in time between the exit of the stack and the point of interest (the characteristic dilution time was determined from the tracer data). Second, no ozone was taken to be present and only the oxidation of NO by O_2 was considered. This model is expected to give the lowest possible NO_2 concentration. With an initial concentration of 200 ppm NO, this model predicts that the $(NO_2)/[(NO)+(NO_2)]$ ratio after 60 minutes of travel is 0.38.

The second model also assumes that a parcel of air dilutes exponentially in time between the exit of the stack and the point of interest. However,

TABLE 10

Peak One-Hour Averaged Equivalent Concentrations

Test	SO_2 (ppm)	NO_2 (ppm)
Moss Landing Test No. 1	0.009	0.008
Moss Landing Test No. 2	0.063	0.043
Moss Landing Test No. 3	0.0002	0.019
Long Beach Test No. 1	0.12	0.12
Long Beach Test No. 2	0.044	0.038
Long Beach Test No. 3	0.063	0.059
Long Beach Test No. 4	0.048	0.047
Long Beach Test No. 5	0.13	0.11
Long Beach Test No. 6	0.064	0.053

The California hourly-averaged standards are currently 0.5 ppm for SO_2 and 0.25 ppm for NO_2.

in this case the fast oxidation of NO to NO_2 by O_3 is considered. Assuming a very low constant O_3 concentration of 0.001 ppm, after 60 minutes the $(NO_2)/[(NO)+(NO_2)]$ ratio is 0.82. It should be noted that higher O_3 concentrations yield essentially 100% NO_2. Details of this calculation are given in Appendix A-6.

This second model is certainly idealized since the ozone concentration will not remain constant due to reaction. Davis et al. (1974) presented experimental data on the conversion of NO from a power plant to NO_2; aircraft measurements indicated that after 60 minutes of travel, the $(NO_2)/[(NO)+(NO_2)]$ ratio was 0.75, with an ambient ozone concentration of about 0.08 ppm. These aircraft measurements, however, were taken at an altitude equivalent to the effective stack height, where the very high NO concentrations quickly reduce the ozone concentration to zero.

From the above discussions, it is apparent that after 60 minutes of travel, the amount of NO_2 formed is probably greater than 38% of the total NO_X, and probably less than 100% of the total NO_X. More experimental data is necessary to determine the exact amount of NO_2 which forms from the oxidation of NO released from the power plant. The equivalent NO_2 concentrations in Table 10 were based on 100% conversion to NO_2, and thus represent upper-bound values.

FIGURES

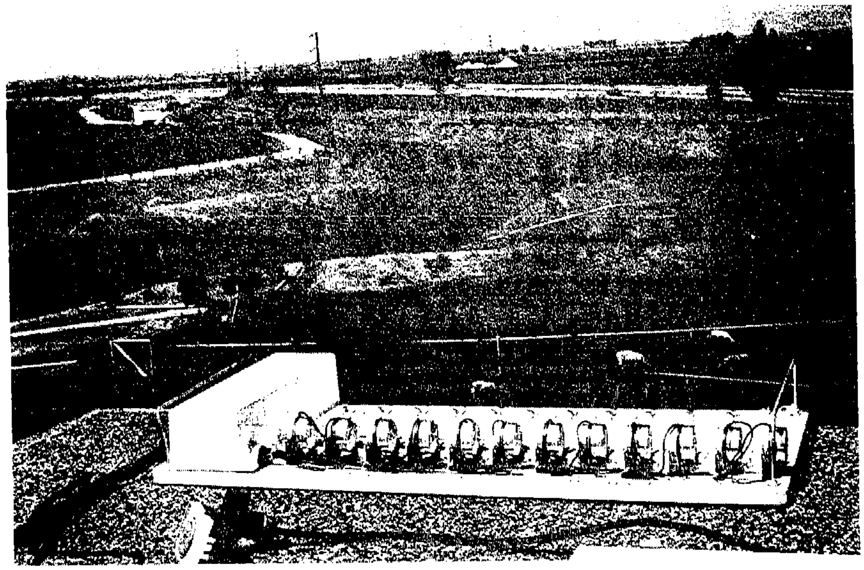

Figure 1. Typical location of an automatic sequential air sampler.

Figure 2. Person adjusting automatic sequential air sampler the day before a test.

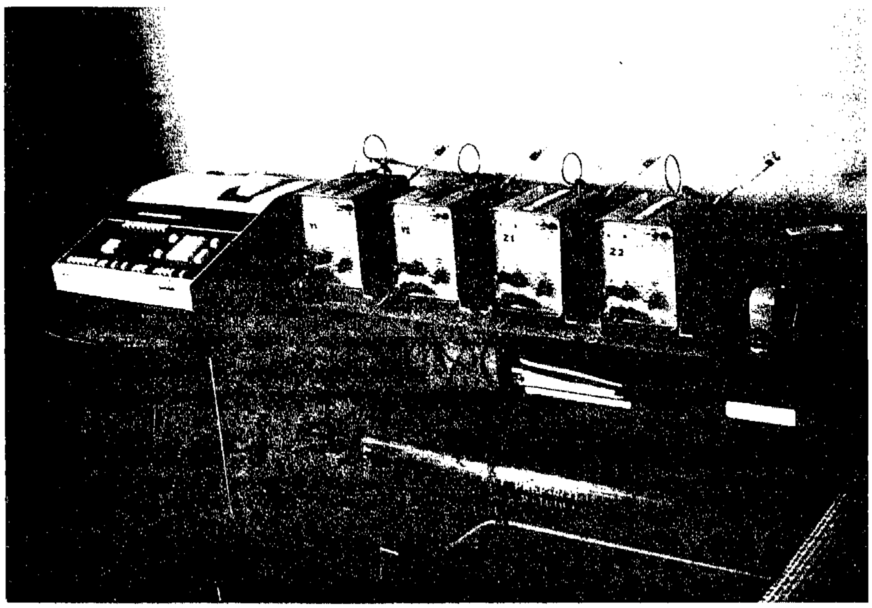

Figure 3. Tracer analysis system involving four gas chromatographs, carrier gas bottle, and electronic integrator located in Salinas motel room.

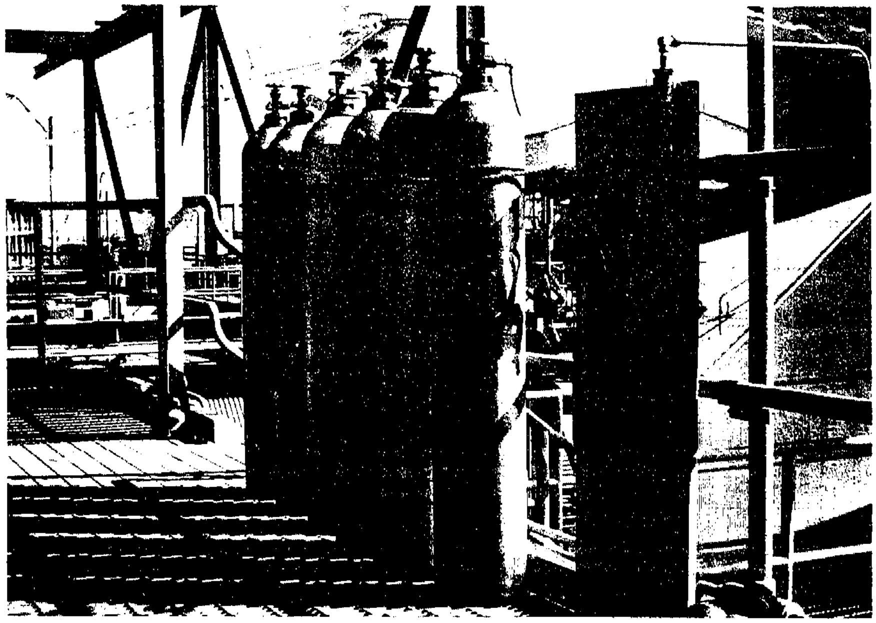

Figure 4. Tracer release system at the Moss Landing power plant.

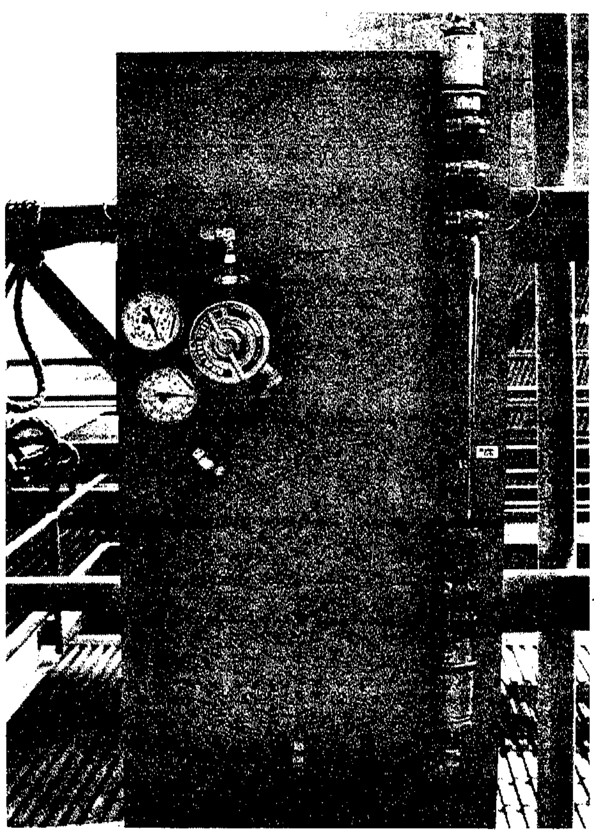

Figure 5. Close-up of regulator and flowmeter assembly of the release system.

Figure **6**. Tracer release system at the Alamitos power plant in Long Beach.

Figure **7**. Weighing a tracer bottle to determine amount released.

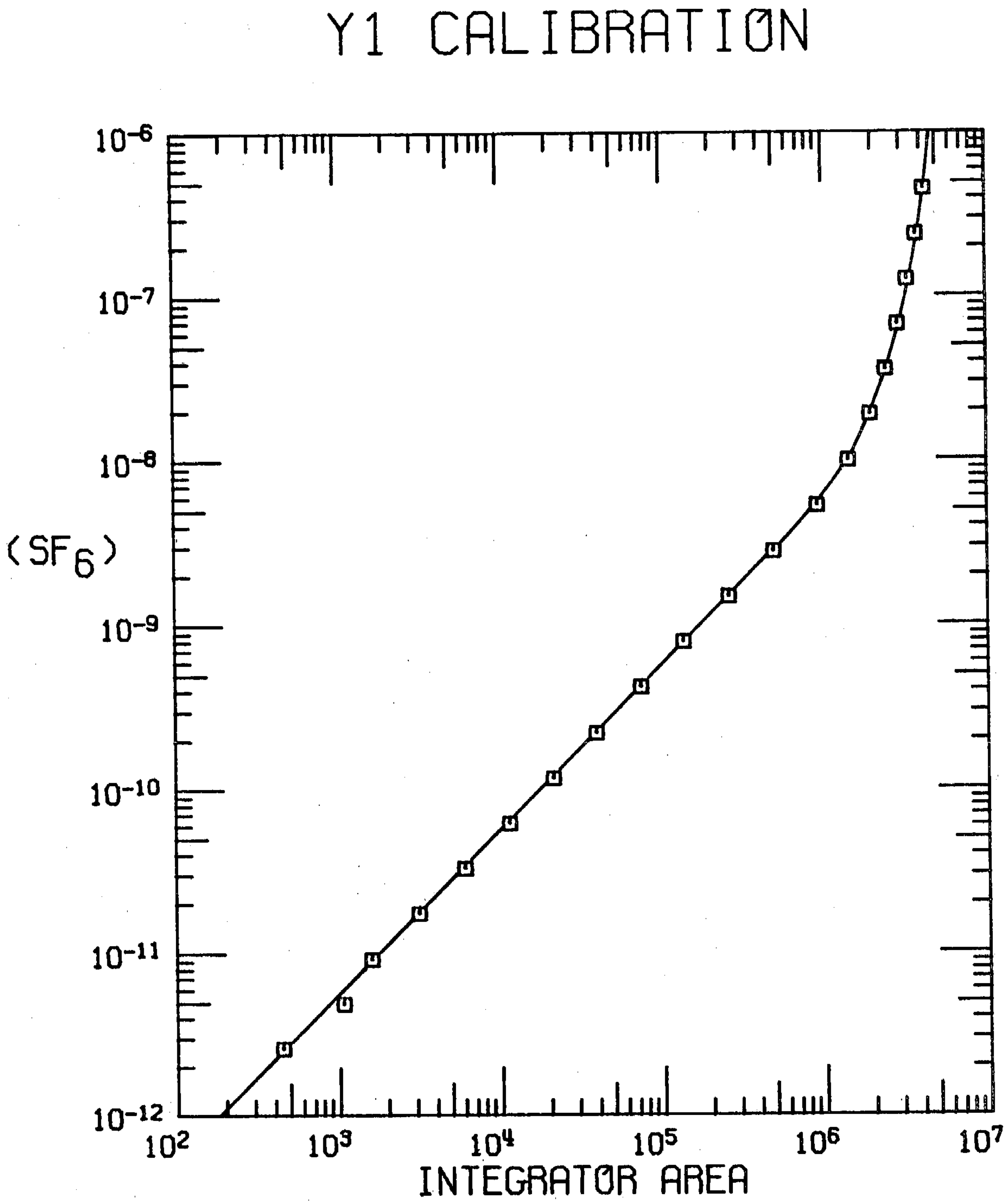

Figure 8. SF_6 calibration curve for Y1 chromatograph (11/20/74).

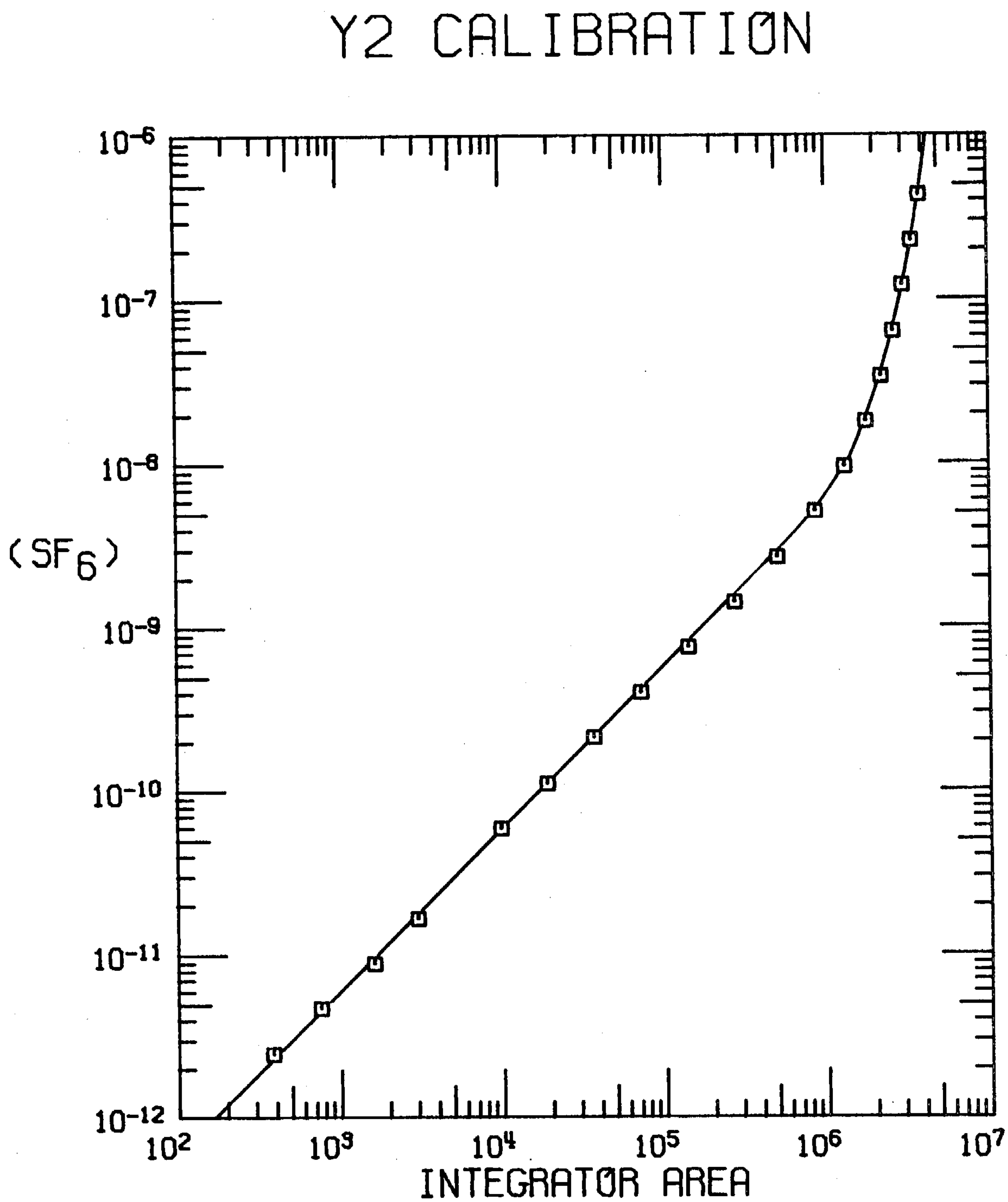

Figure 9. SF_6 calibration curve for Y2 chromatograph (11/20/74).

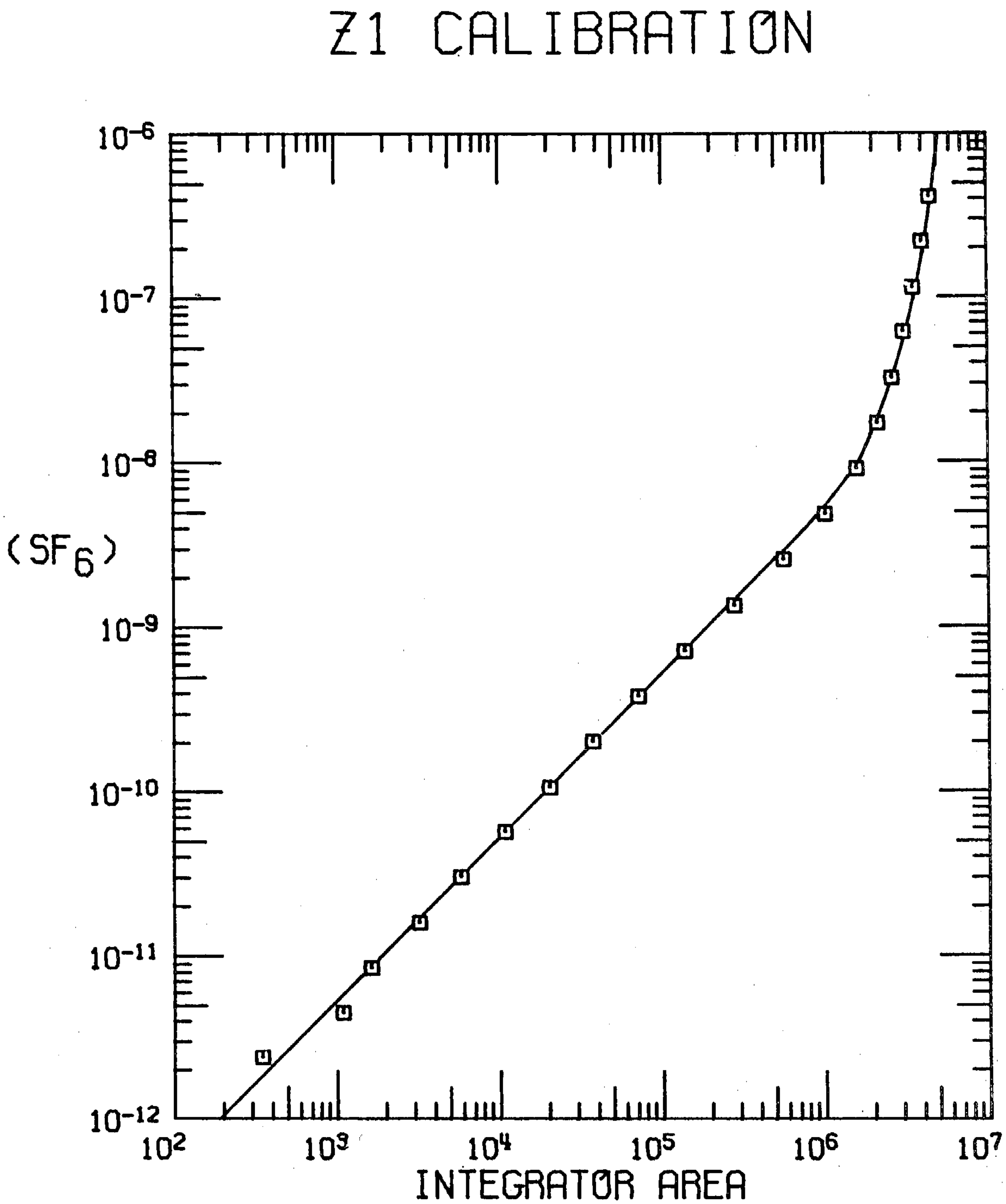

Figure 10. SF_6 calibration curve for Z1 chromatograph (11/20/74).

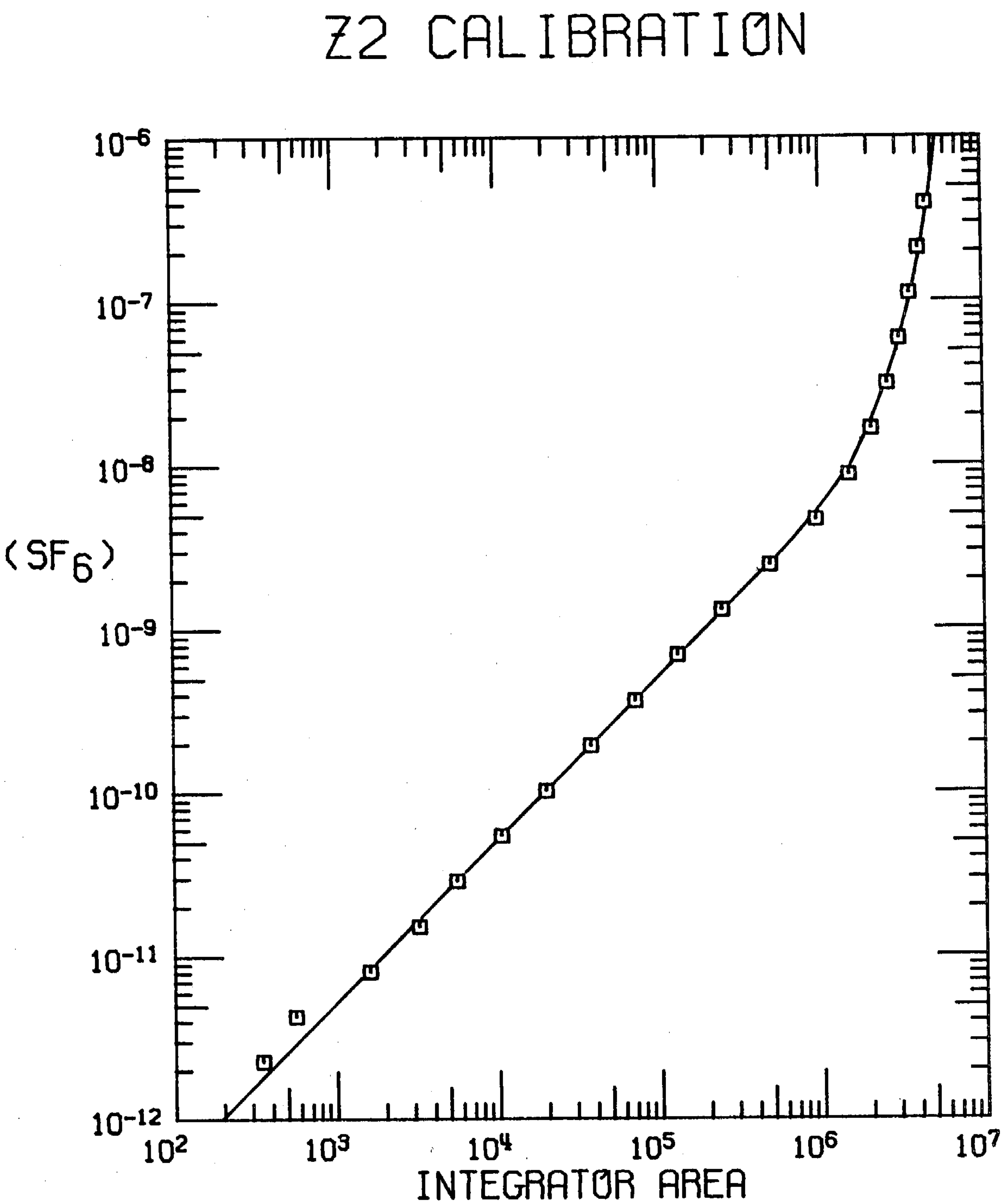

Figure 11. SF_6 calibration curve for Z2 chromatograph (11/20/74).

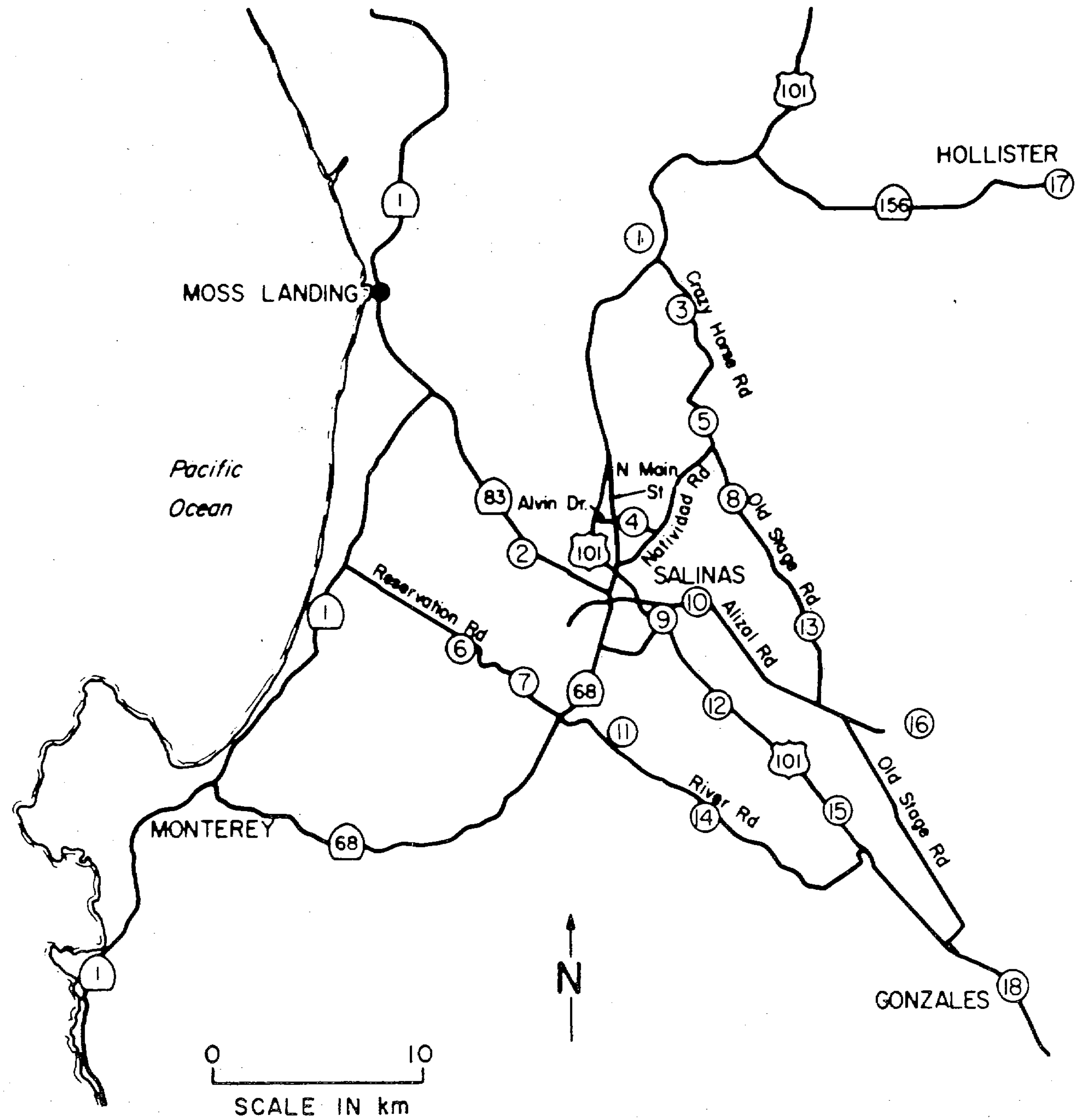

Figure 12. Location of sequential air samplers in the Moss Landing-Salinas area.

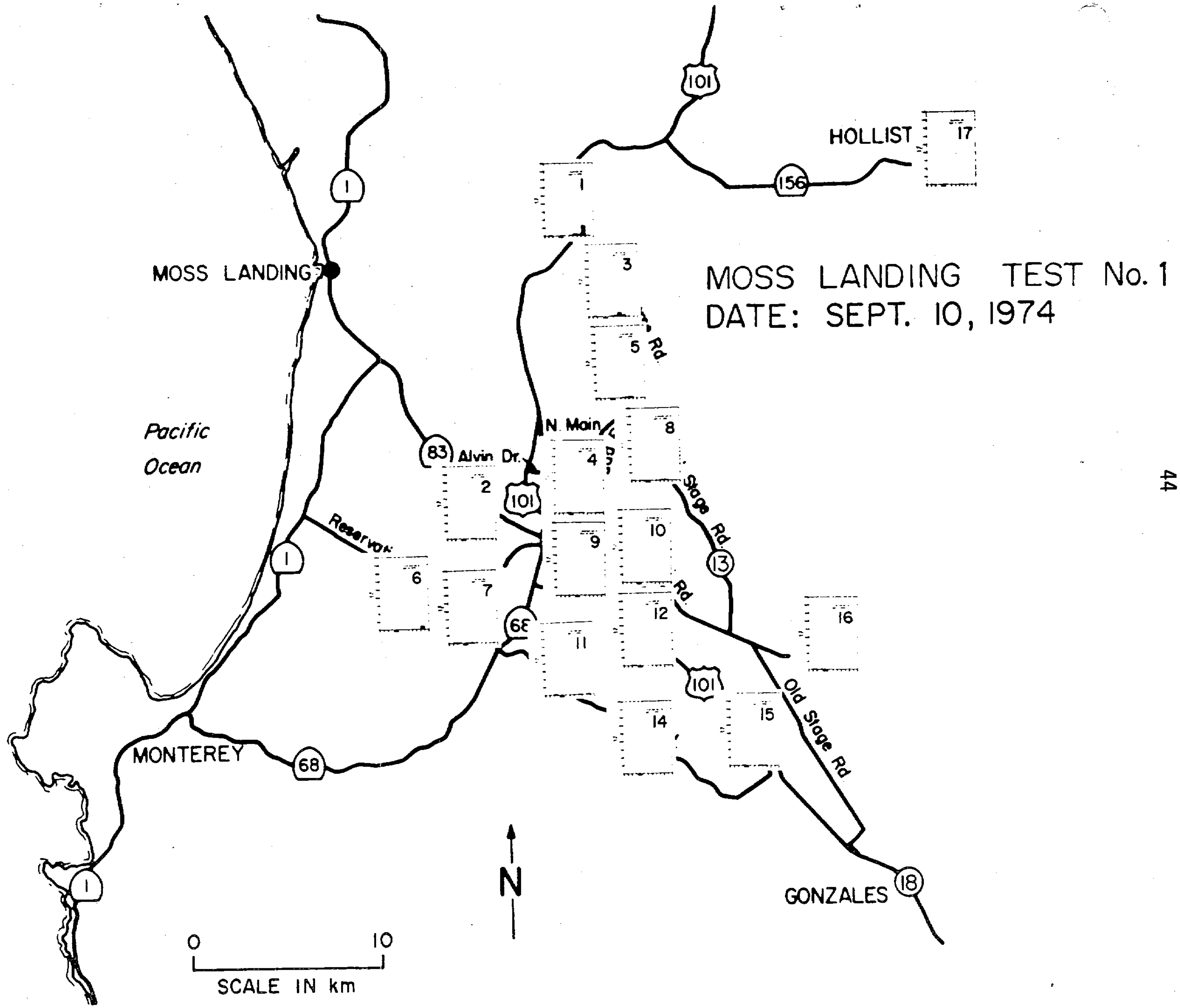

Figure 13. Overview of results for Moss Landing Test No. 1; the SF_6 scale ranges from 0-450 ppt and the time scale ranges from 8 a.m. to 8 p.m. (PDT).

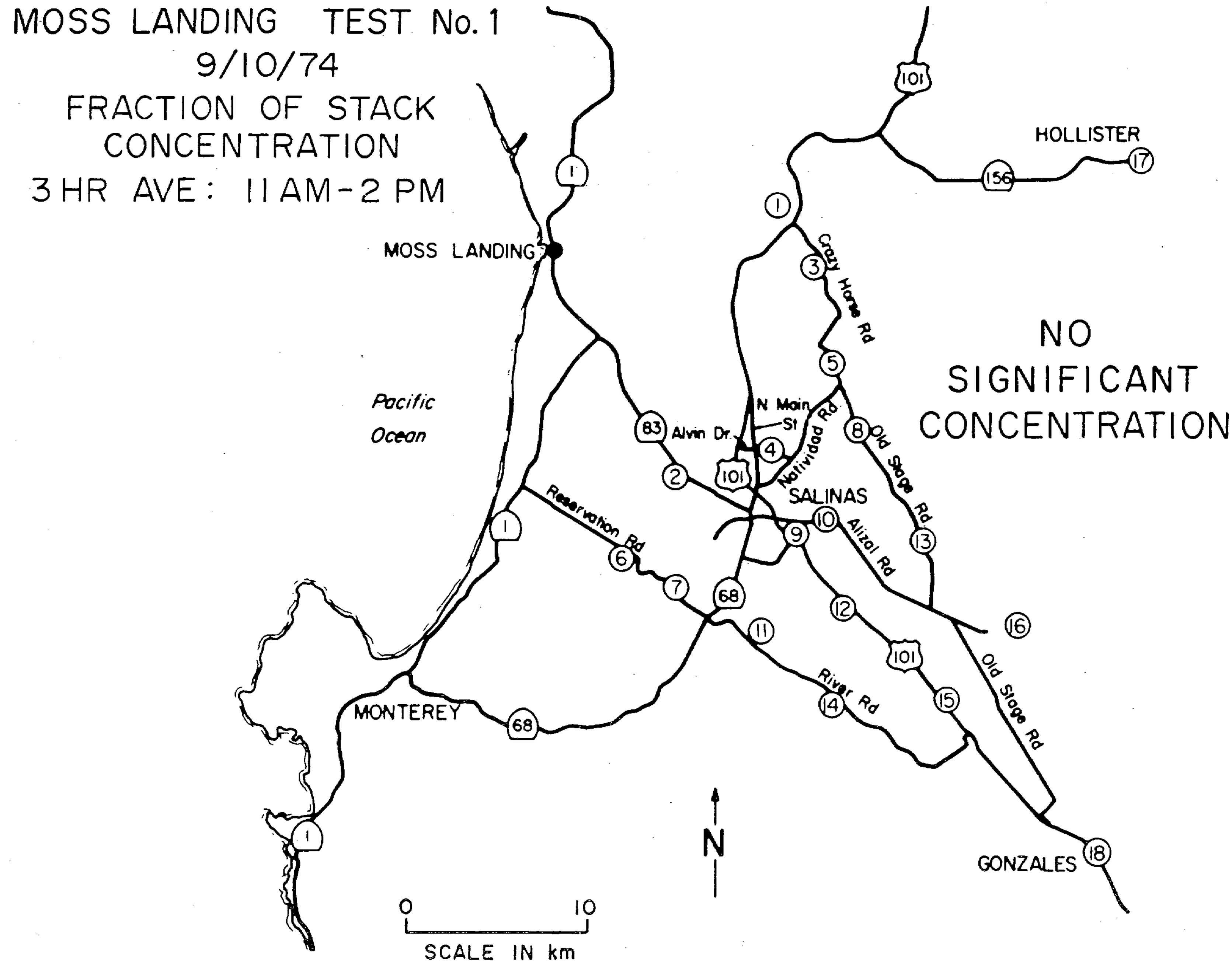

Figure 14. Three-hour averaged concentration isopleths for Moss Landing Test No. 1: 11 a.m. to 2 p.m. (PDT).

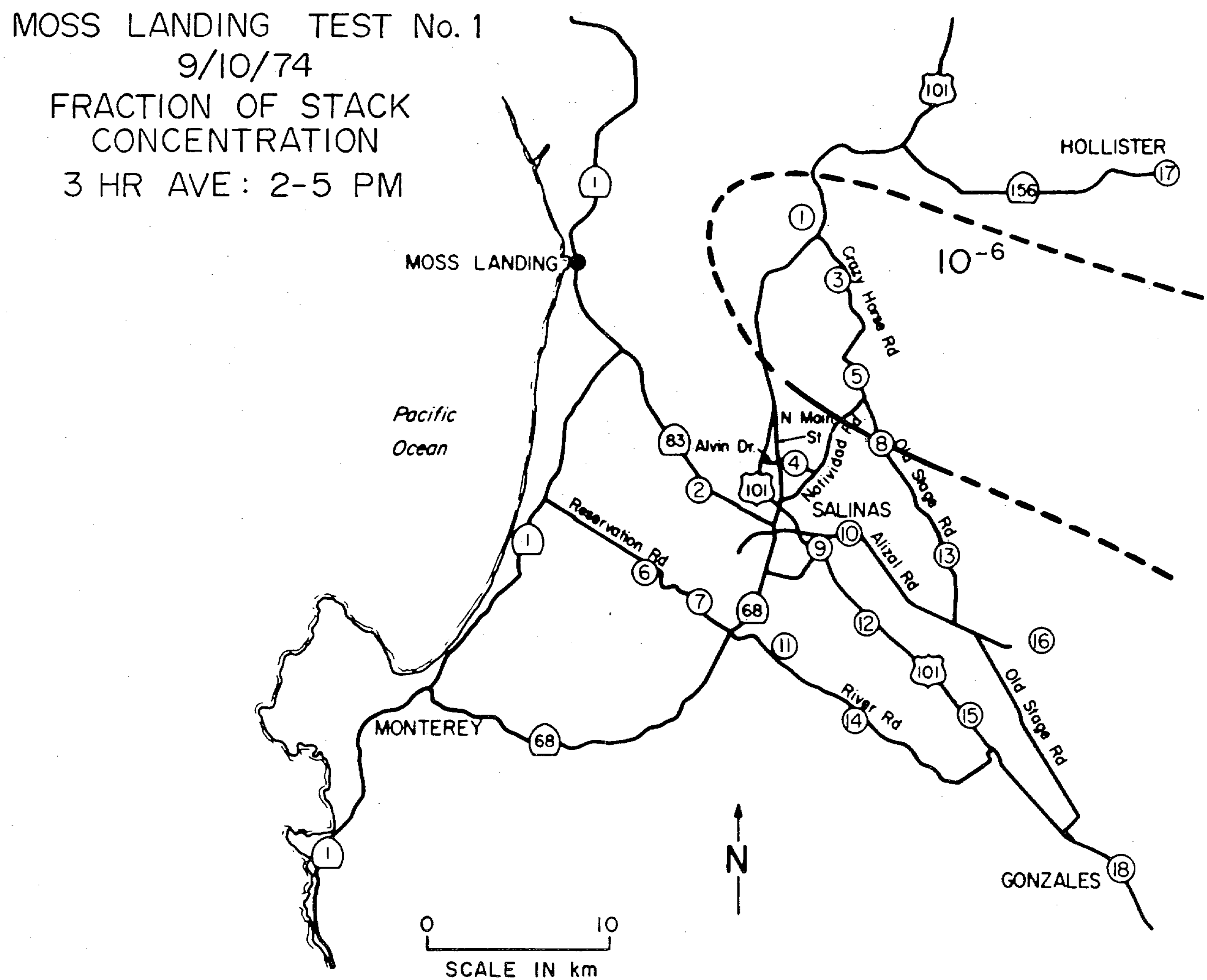

Figure 15. Three-hour averaged concentration isopleths for Moss Landing Test No. 1: 2 p.m. to 5 p.m. (PDT).

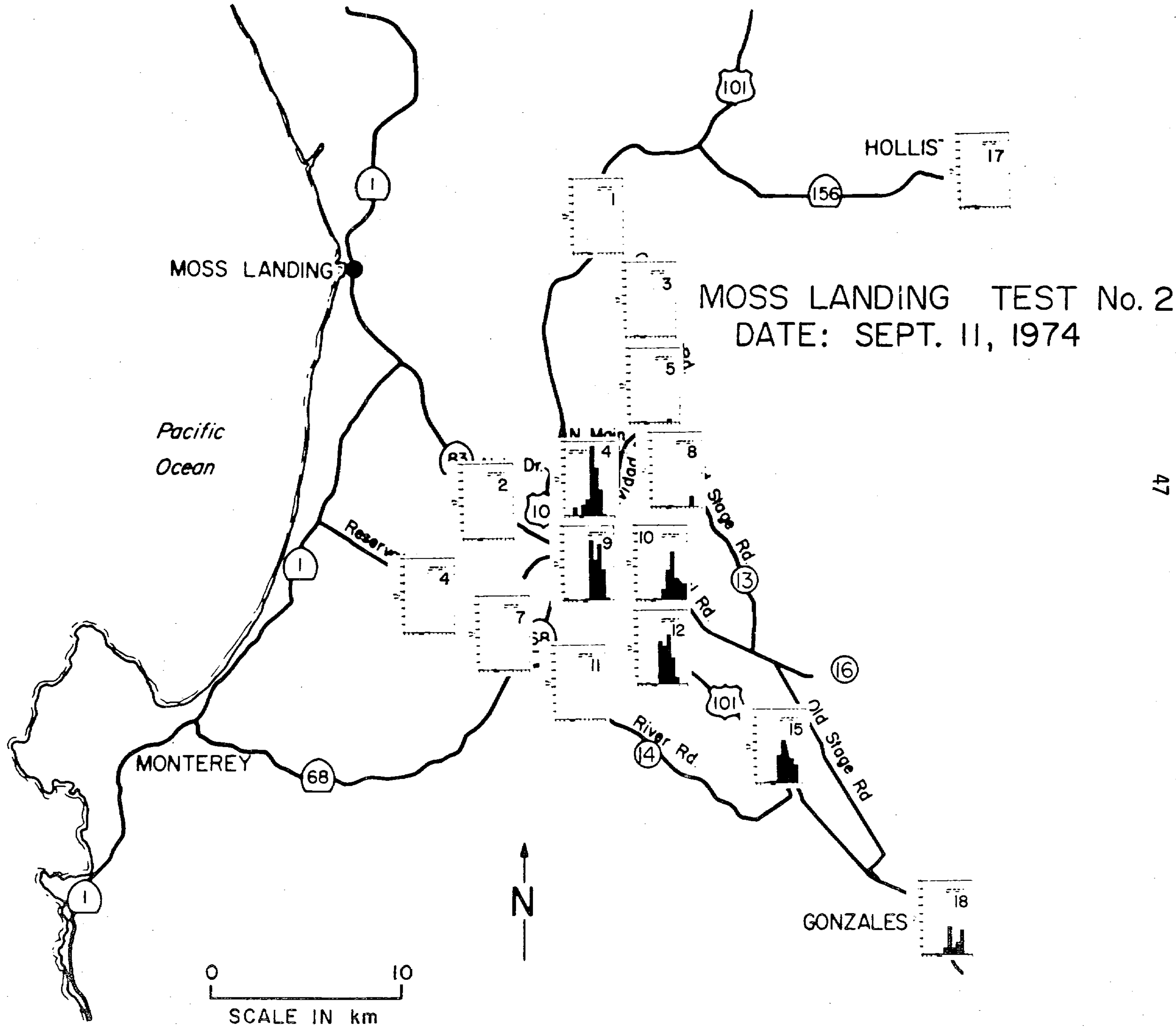

Figure 16. Overview of results for Moss Landing Test No. 2; the SF_6 scale ranges from 0-450 ppt and the time scale ranges from 8 a.m. to 8 p.m. (PDT).

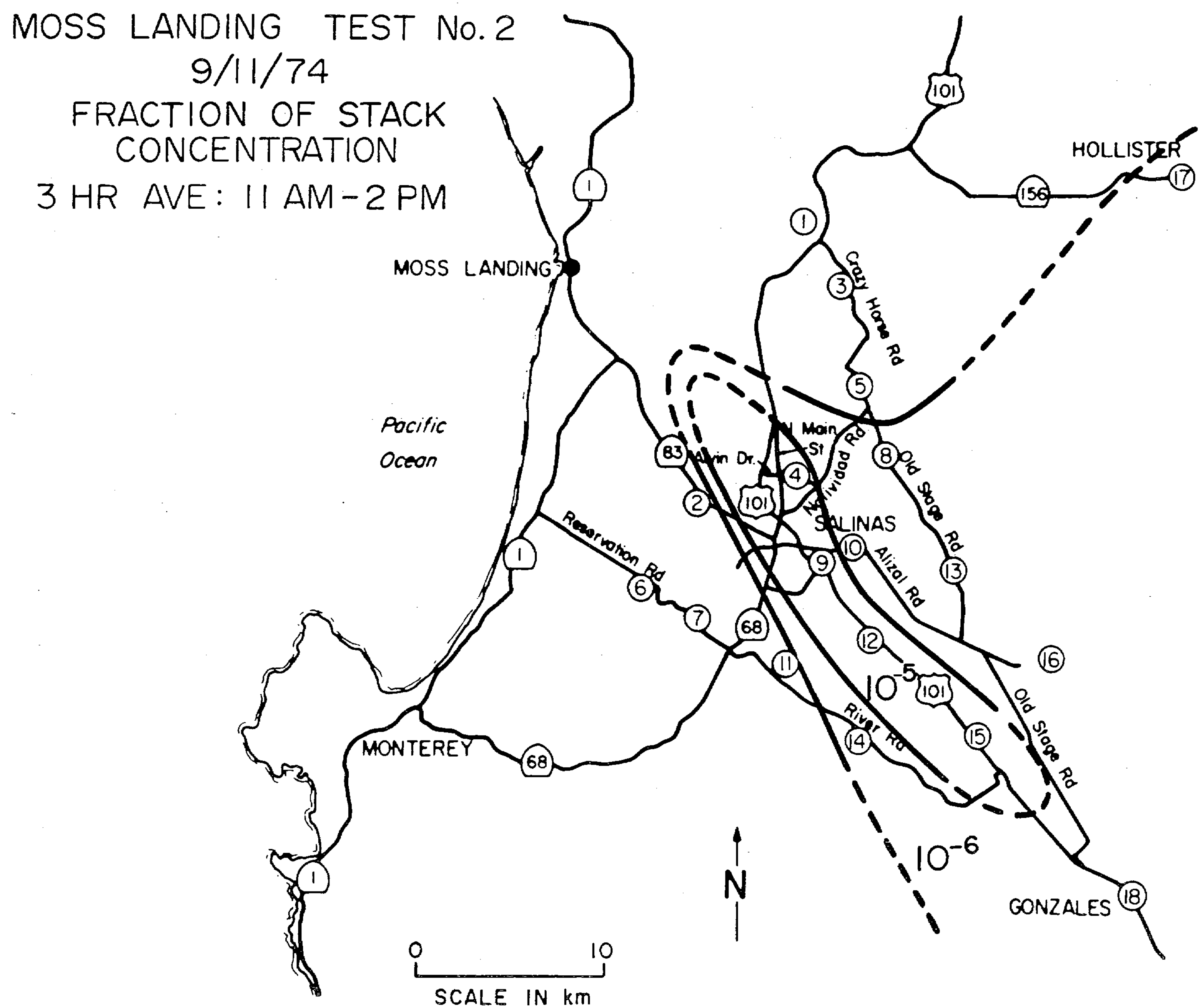

Figure 17. Three-hour averaged concentration isopleths for Moss Landing Test No. 2: 11 a.m. to 2 p.m. (PDT).

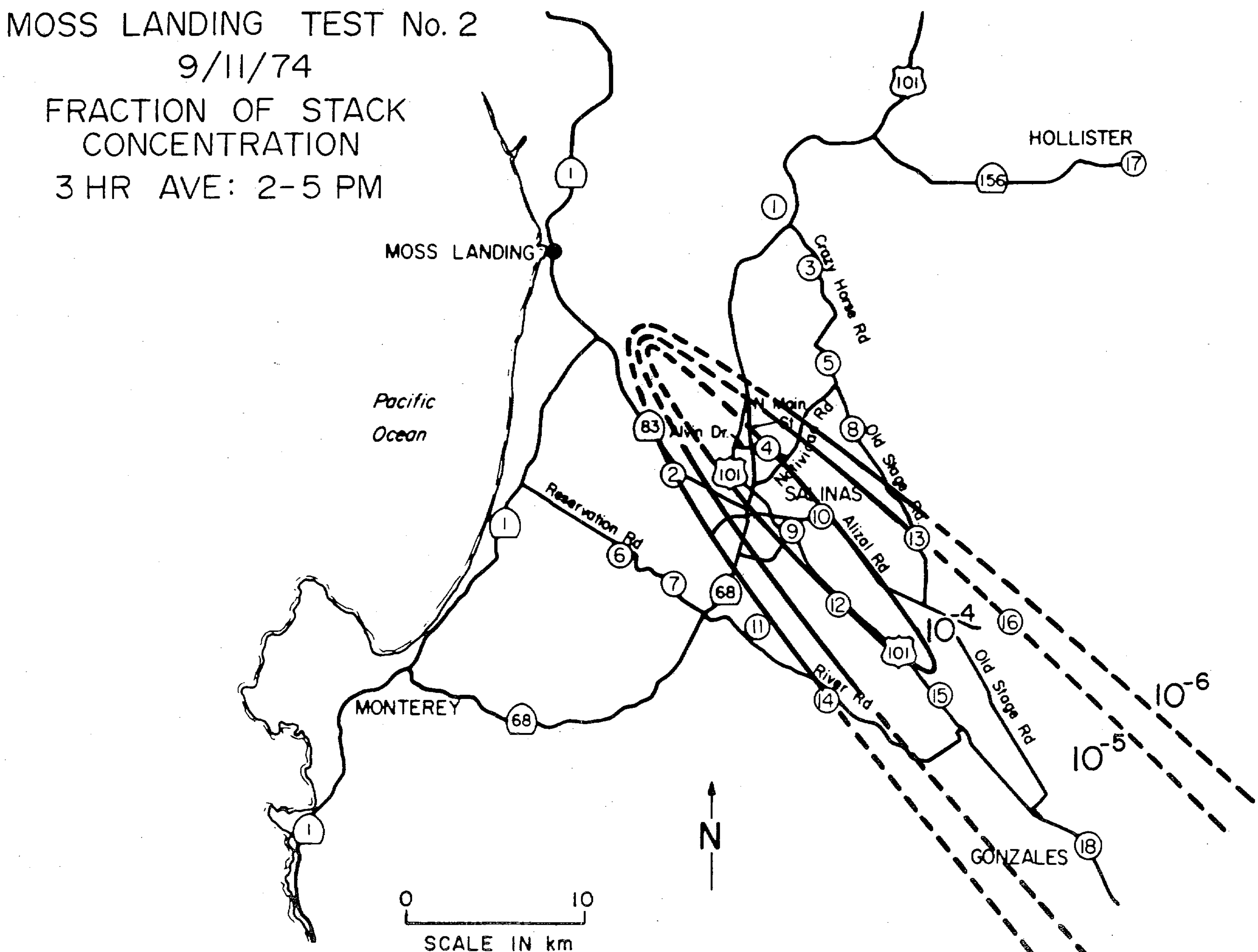

Figure 18. Three-hour averaged concentration isopleths for Moss Landing Test No. 2: 2 p.m. to 5 p.m. (PDT).

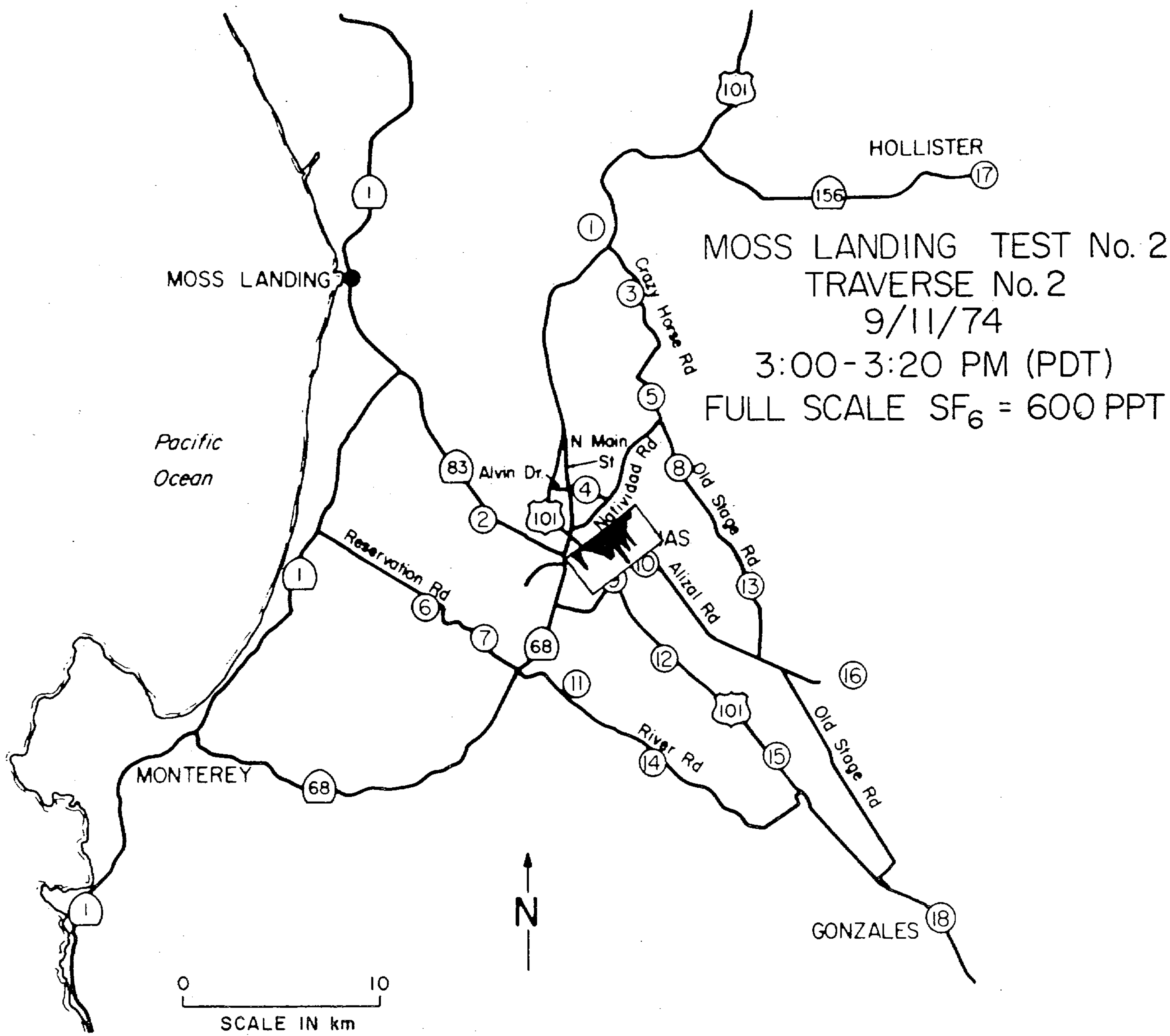

Figure 19. Automobile Traverse No. 2 for Moss Landing Test No. 2.

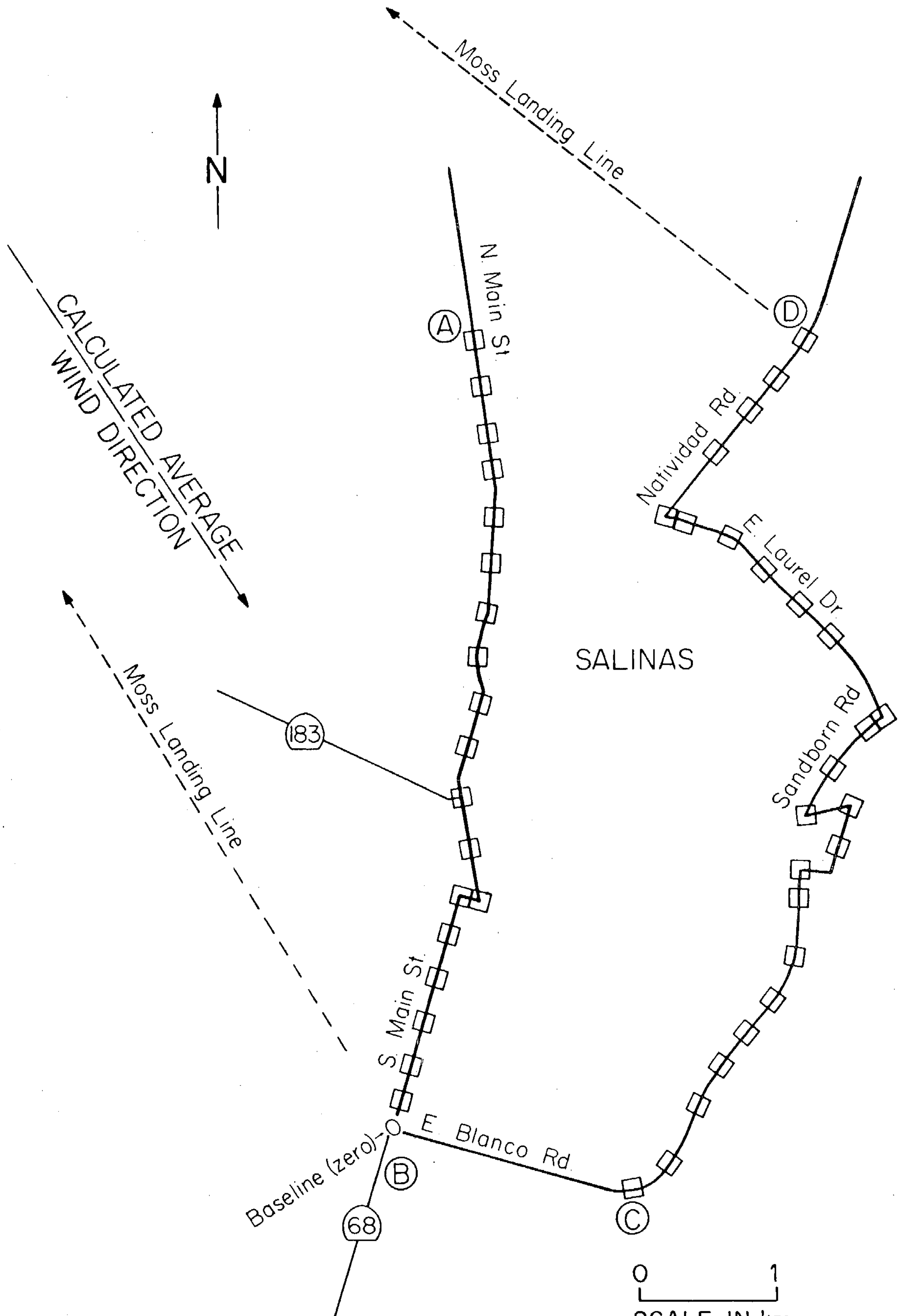

Figure 20. Positions along which Traverses No. 1 and No. 2 were obtained for Moss Landing Test No. 2.

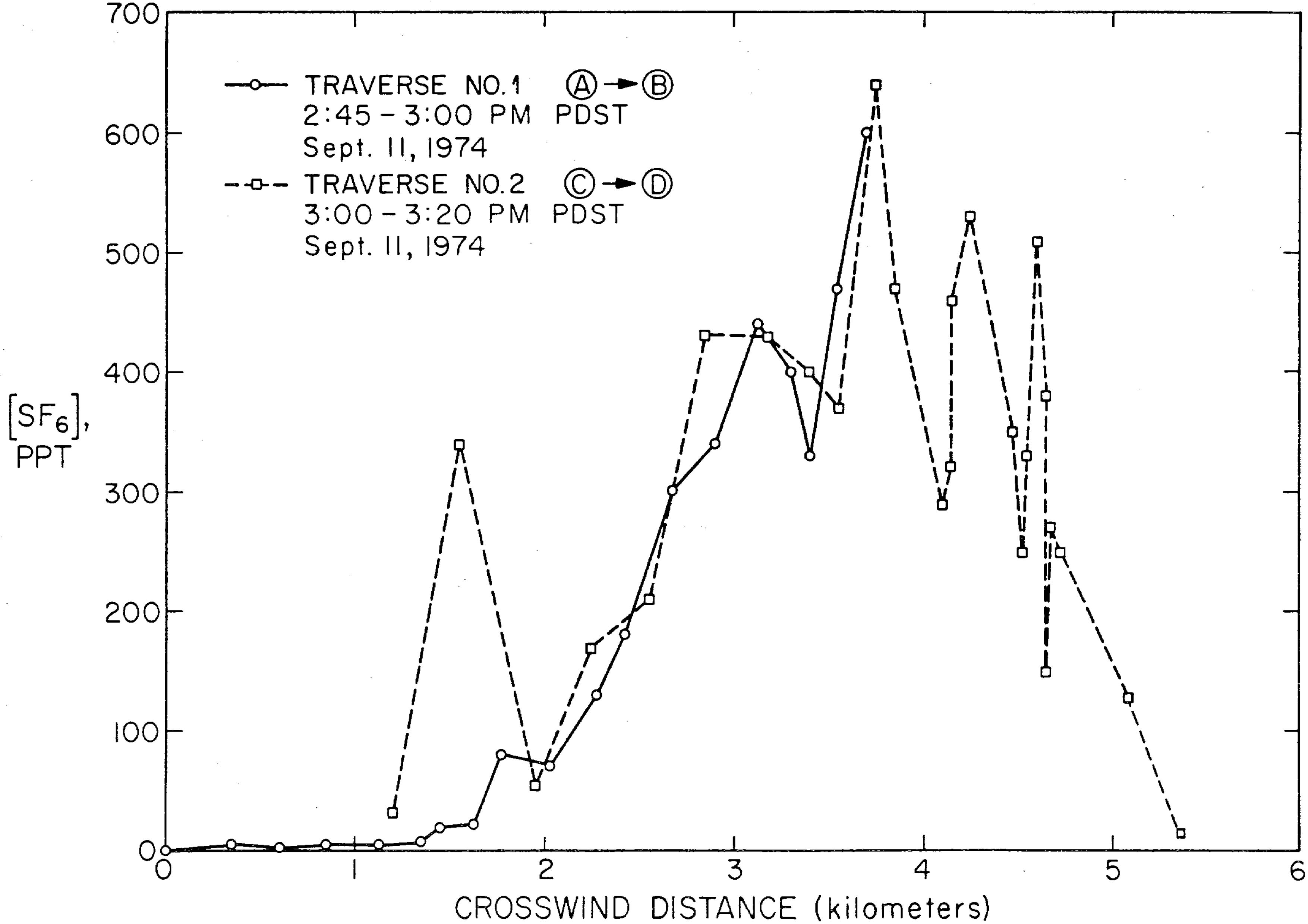

Figure 21. Superposition of Traverses No. 1 and No. 2 to obtain average wind direction for Moss Landing Test No. 2.

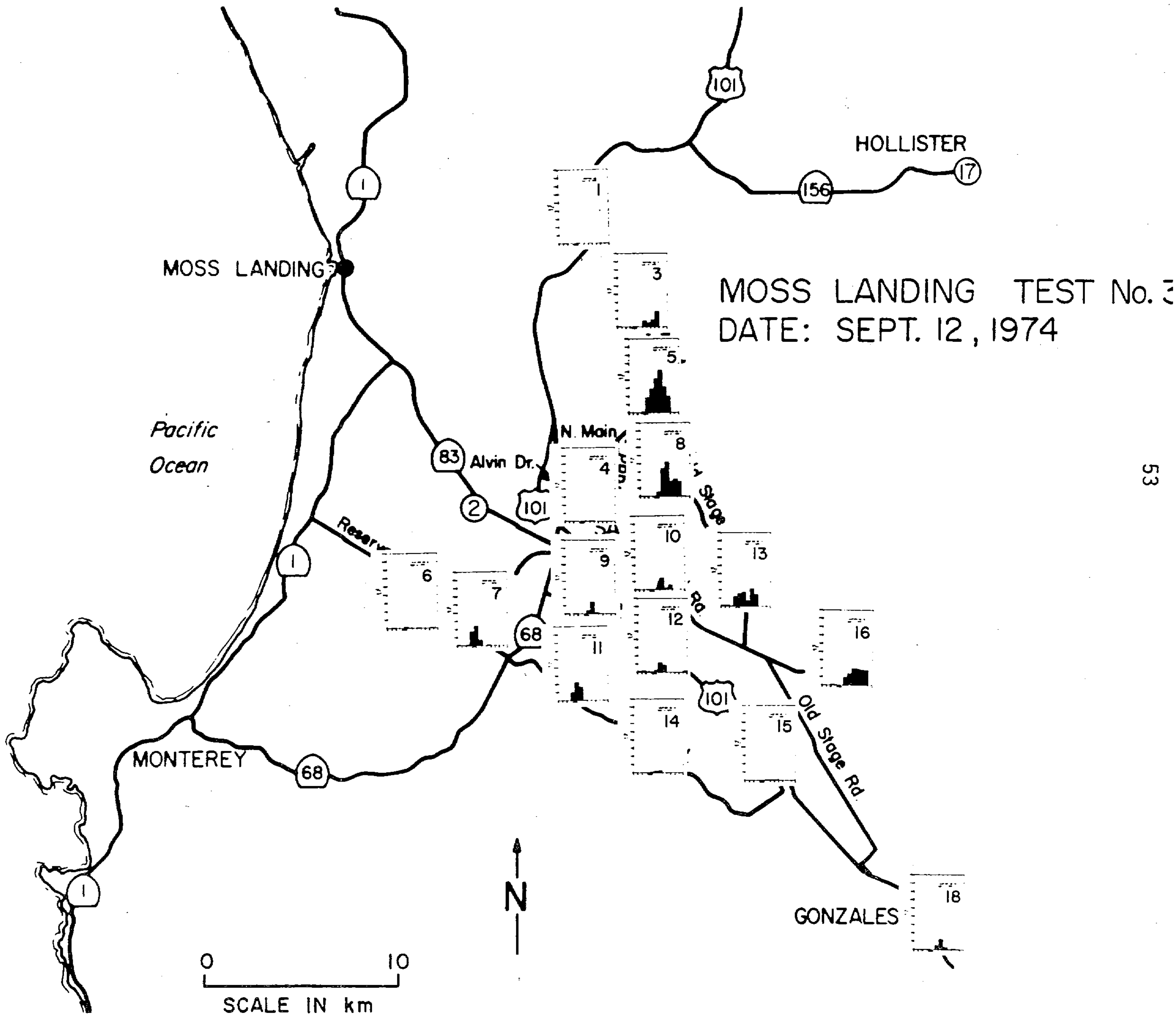

Figure 22. Overview of results for Moss Landing Test No. 3; the SF_6 scale ranges from 0-450 ppt and the time scale ranges from 8 a.m. to 8 p.m. (PDT).

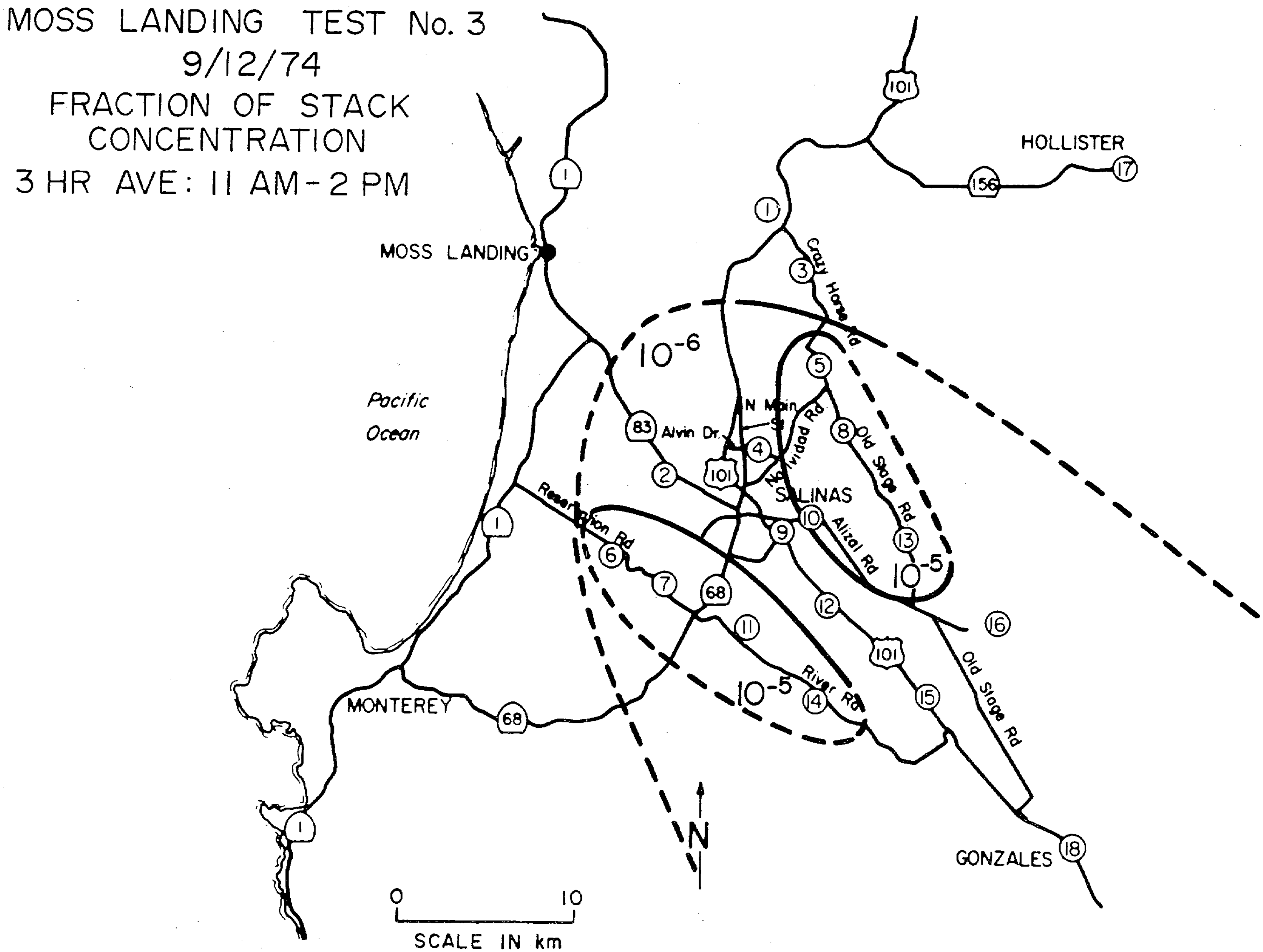

Figure 23. Three-hour averaged concentration isopleths for Moss Landing Test No. 3: 11 a.m. to 2 p.m. (PDT).

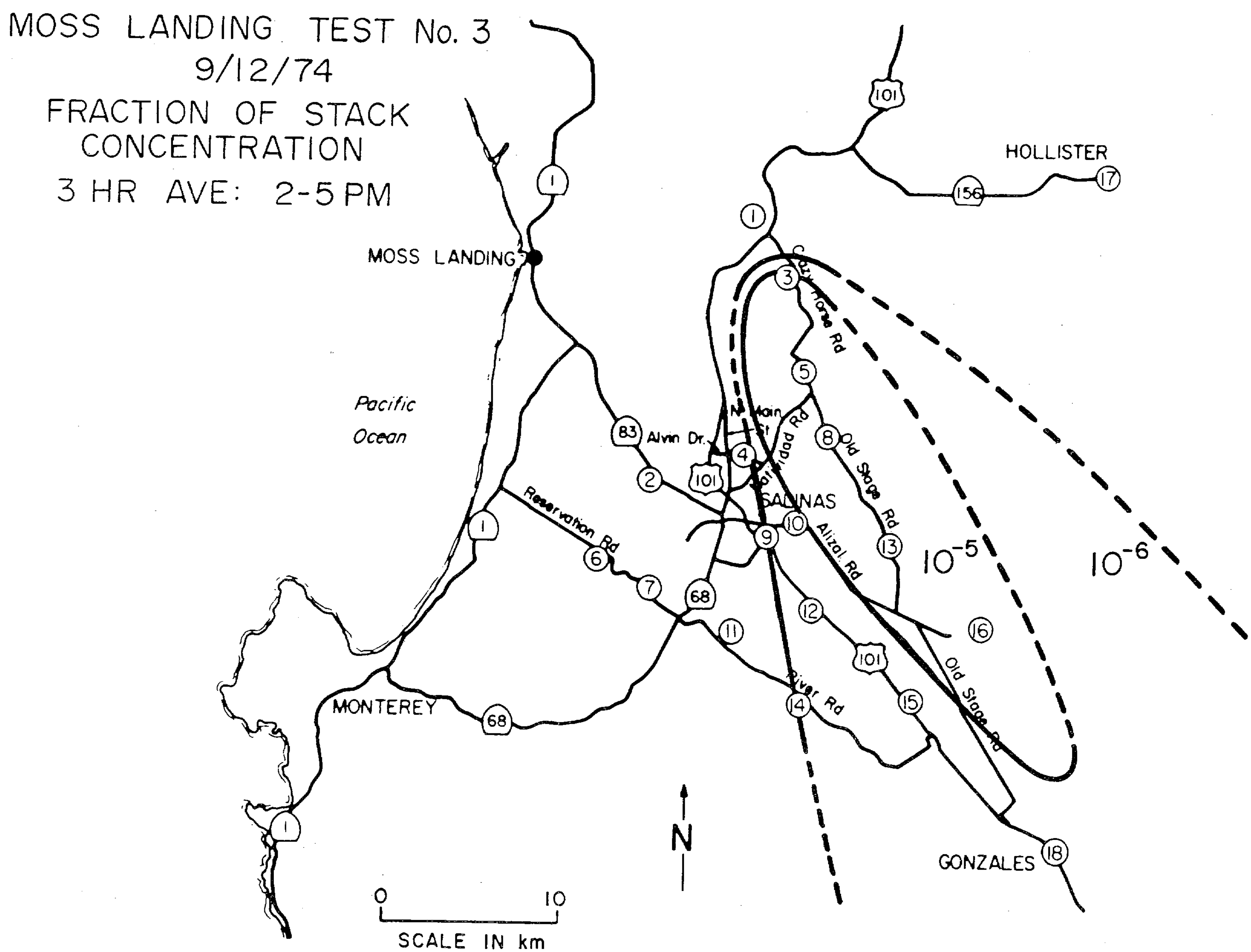

Figure 24. Three-hour averaged concentration isopleths for Moss Landing Test No. 3: 2 p.m. to 5 p.m. (PDT).

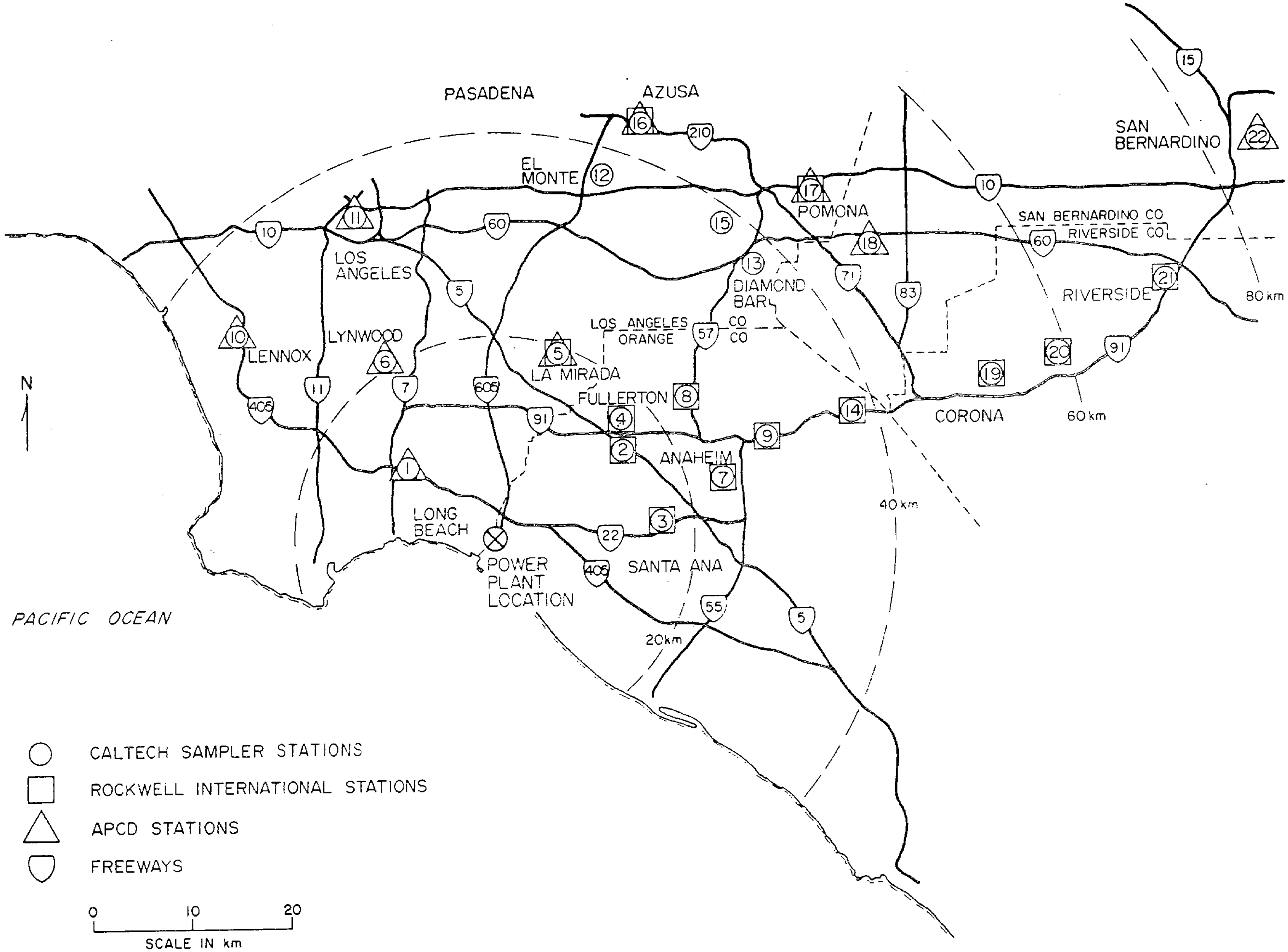

Figure 25. Sampling locations for tests conducted from the Long Beach power plants.

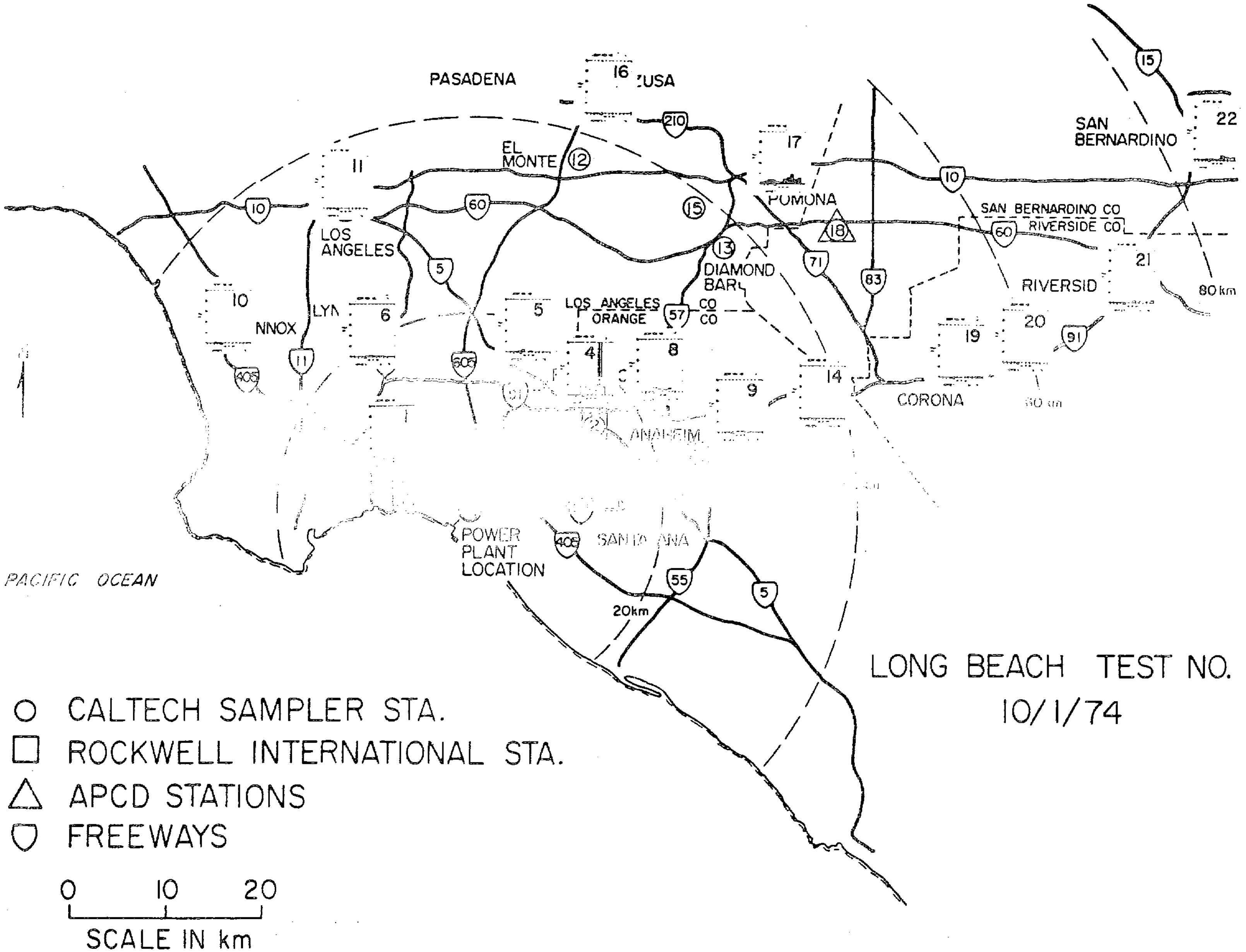

Figure 26. Overview of results for Long Beach Test No. 1; the SF_6 scale ranges from 0-250 ppt and the time scale ranges from 8 a.m. to 8 p.m. (PST).

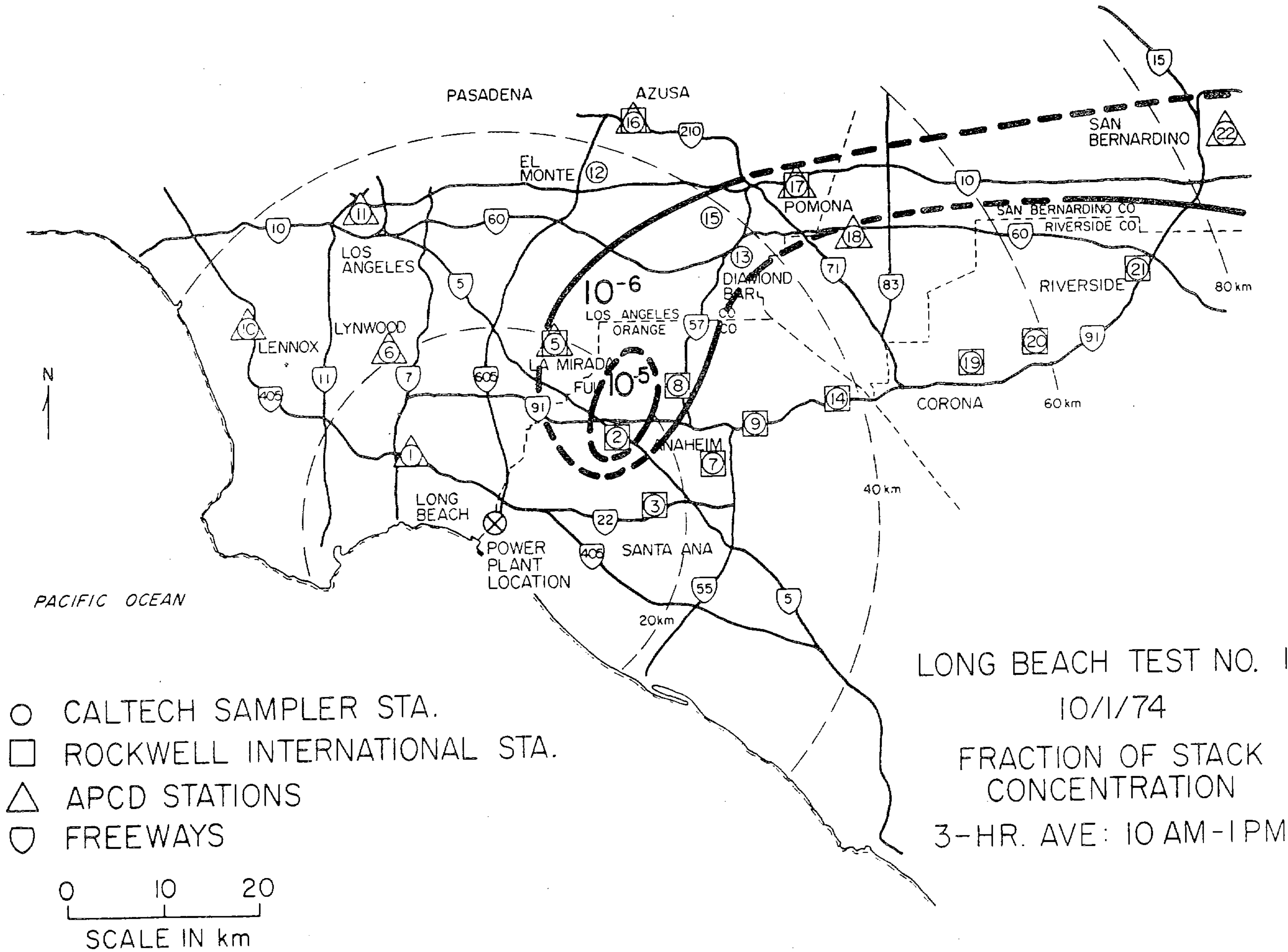

Figure 27. Three-hour averaged concentration isopleths for Long Beach Test No. 1: 10 a.m. to 1 p.m. (PST).

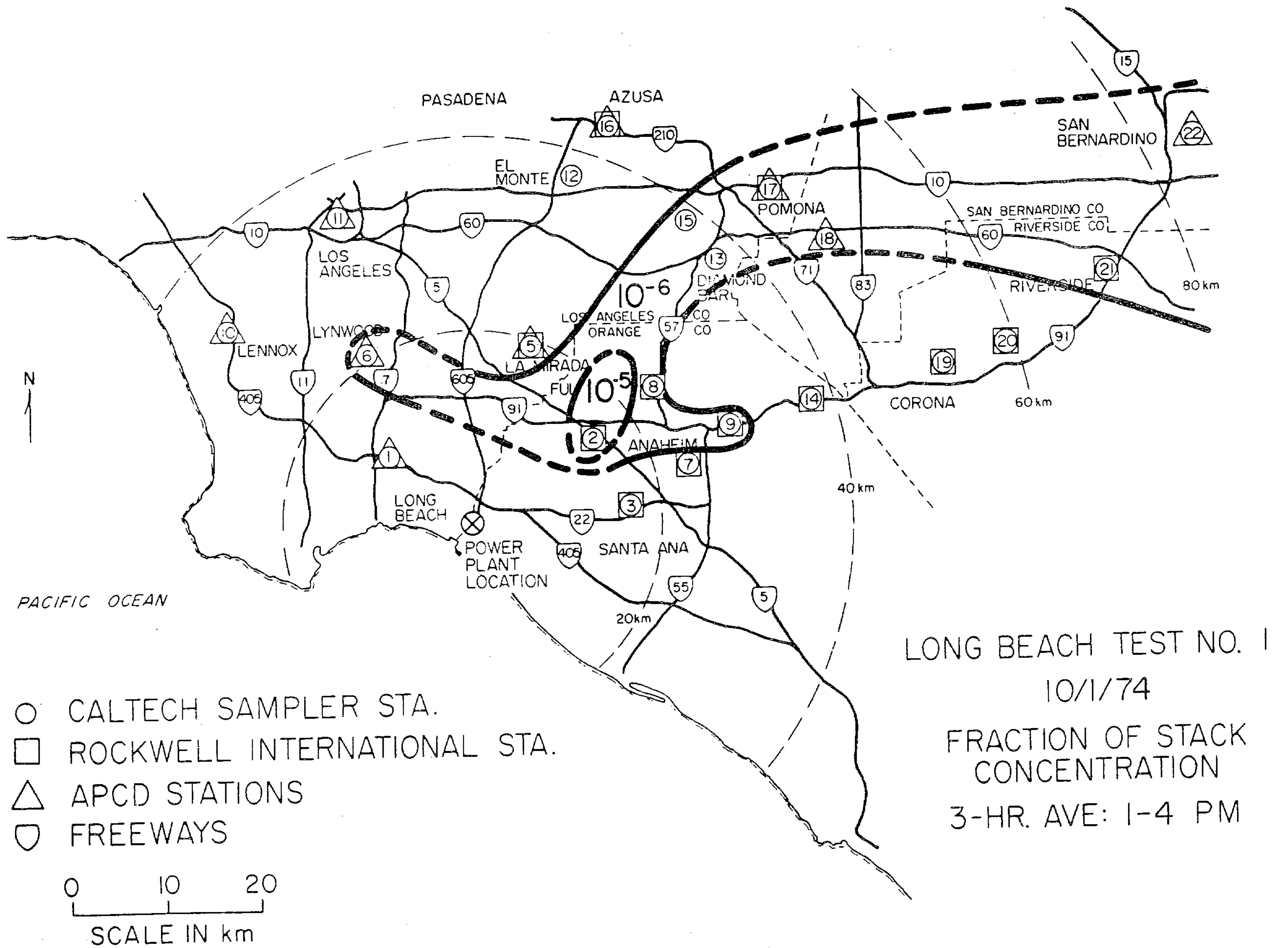

Figure 28. Three-hour averaged concentration isopleths for Long Beach Test No. 1: 1 p.m. to 4 p.m. (PST).

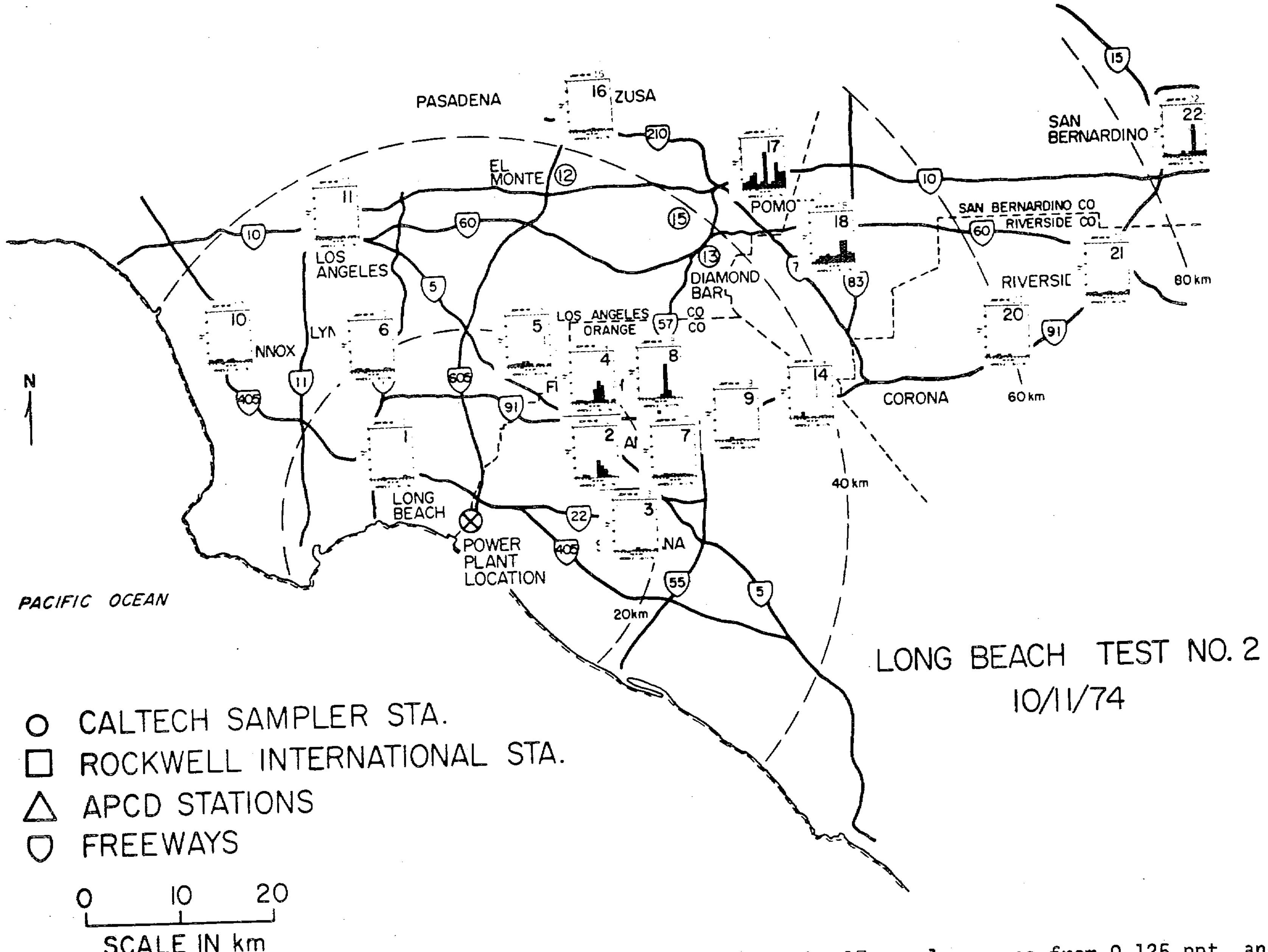

Figure 29. Overview of results for Long Beach Test No. 2; the SF_6 scale ranges from 0-125 ppt, and the time scale ranges from 8 a.m. to 8 p.m. (PST).

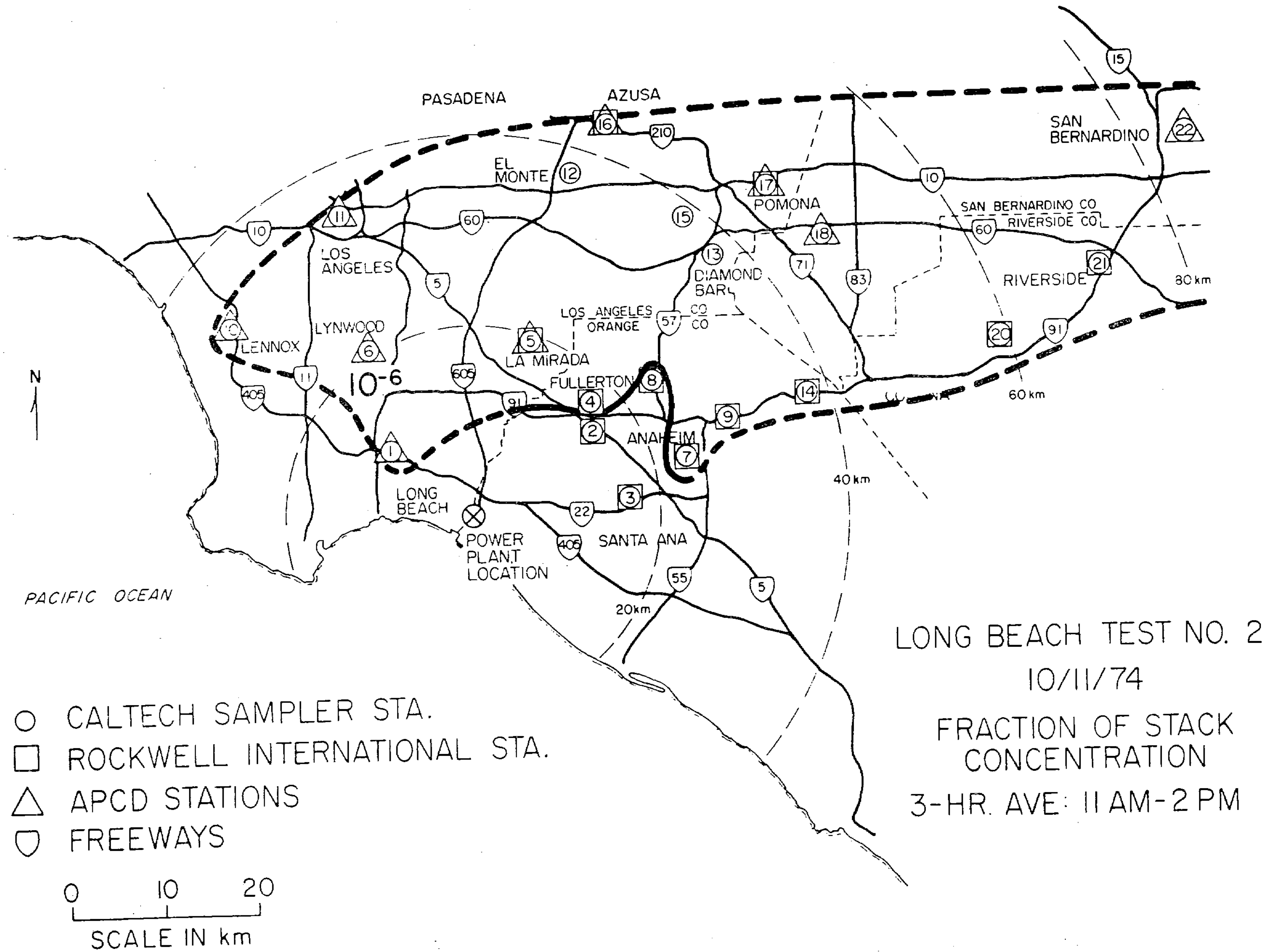

Figure 30. Three-hour averaged concentration isopleths for Long Beach Test No. 2: 11 a.m. to 2 p.m. (PST).

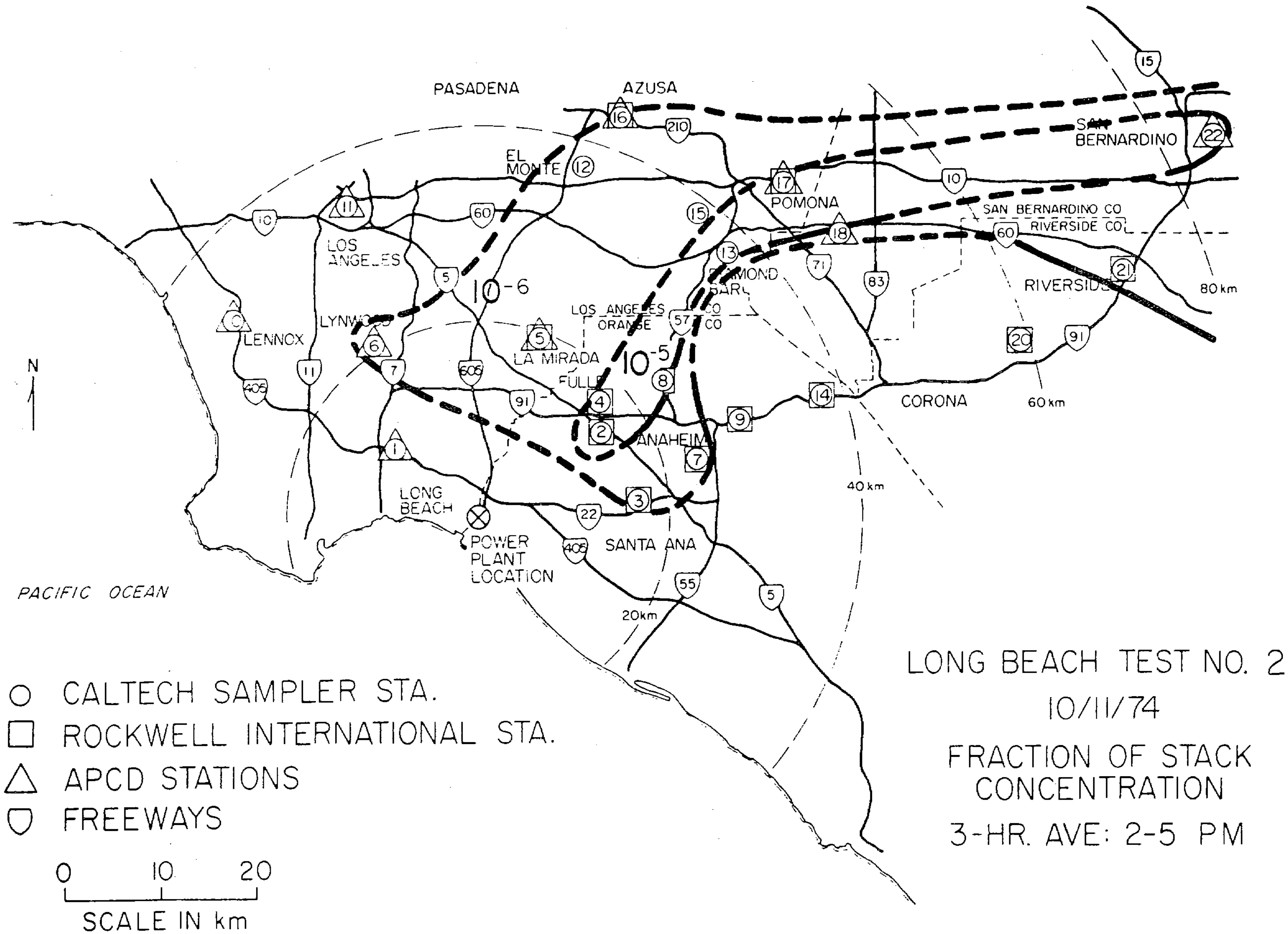

Figure 31. Three-hour averaged concentration isopleths for Long Beach Test No. 2: 2 p.m. to 5 p.m. (PST).

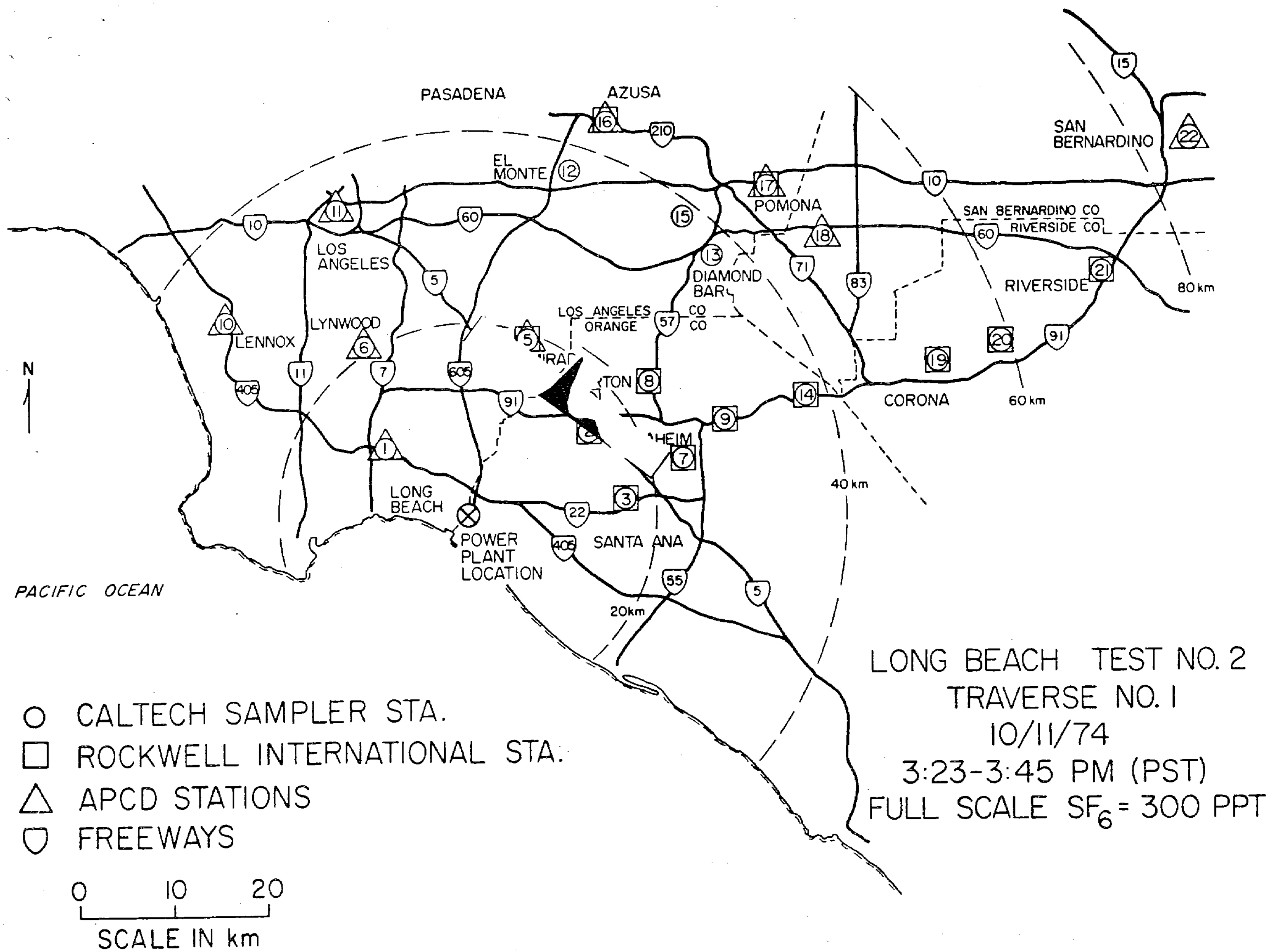

Figure 32. Automobile Traverse No. 1 for Long Beach Test No. 2.

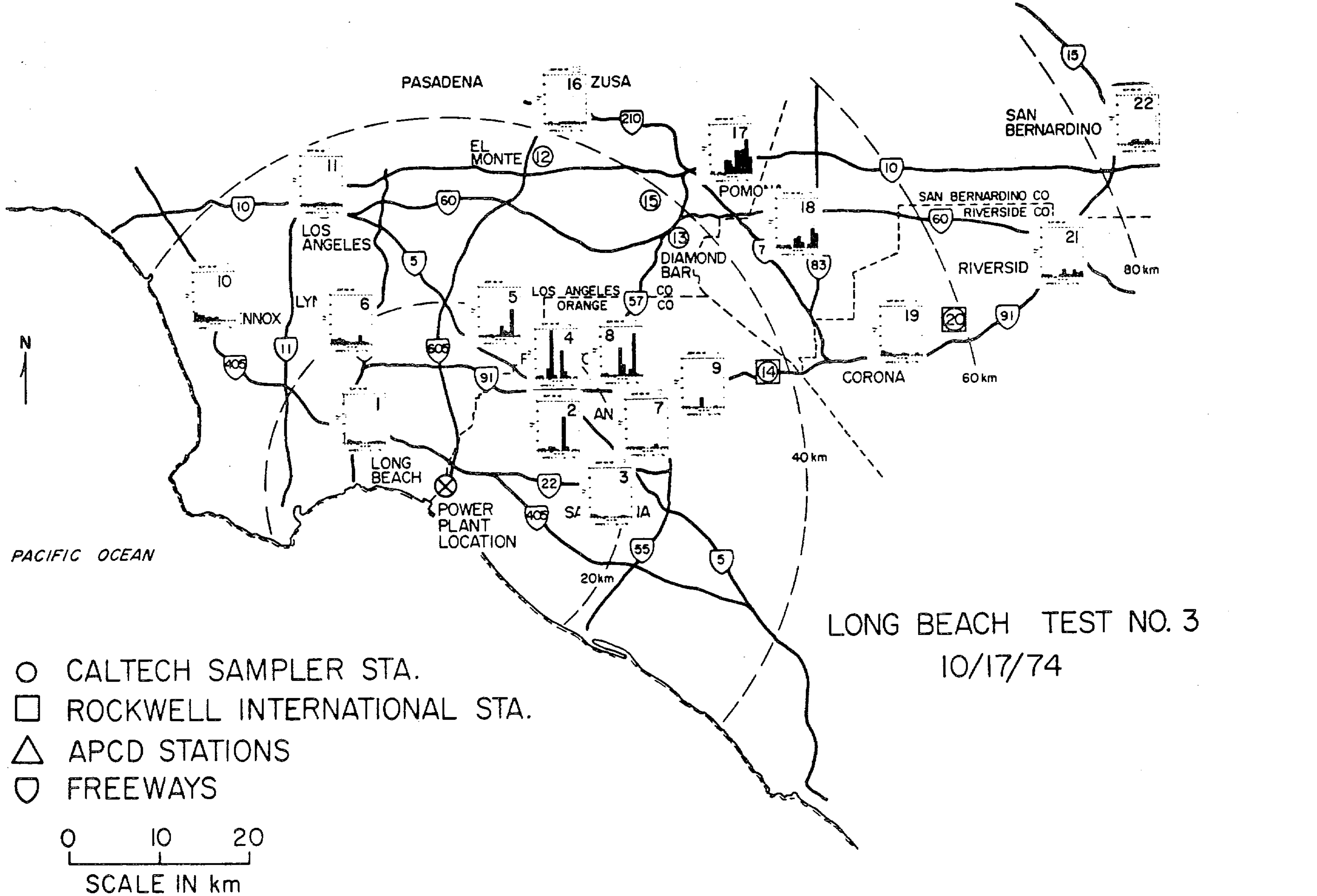

Figure 33. Overview of results for Long Beach Test No. 3; the SF_6 scale ranges from 0-125 ppt and the time scale ranges from 8 a.m. to 8 p.m. (PST).

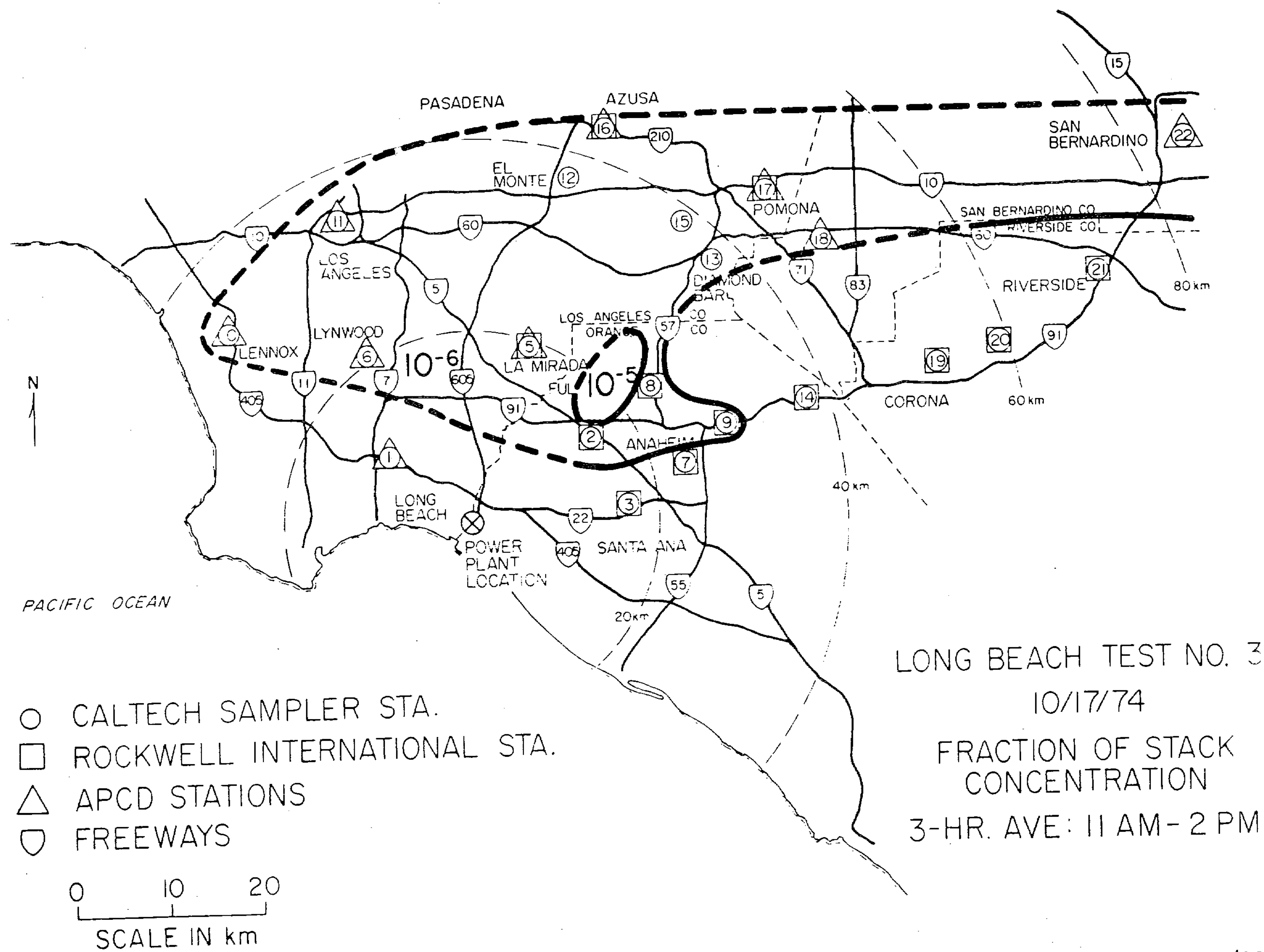

Figure 34. Three-hour averaged concentration isopleths for Long Beach Test No. 3: 11 a.m. to 2 p.m. (PST).

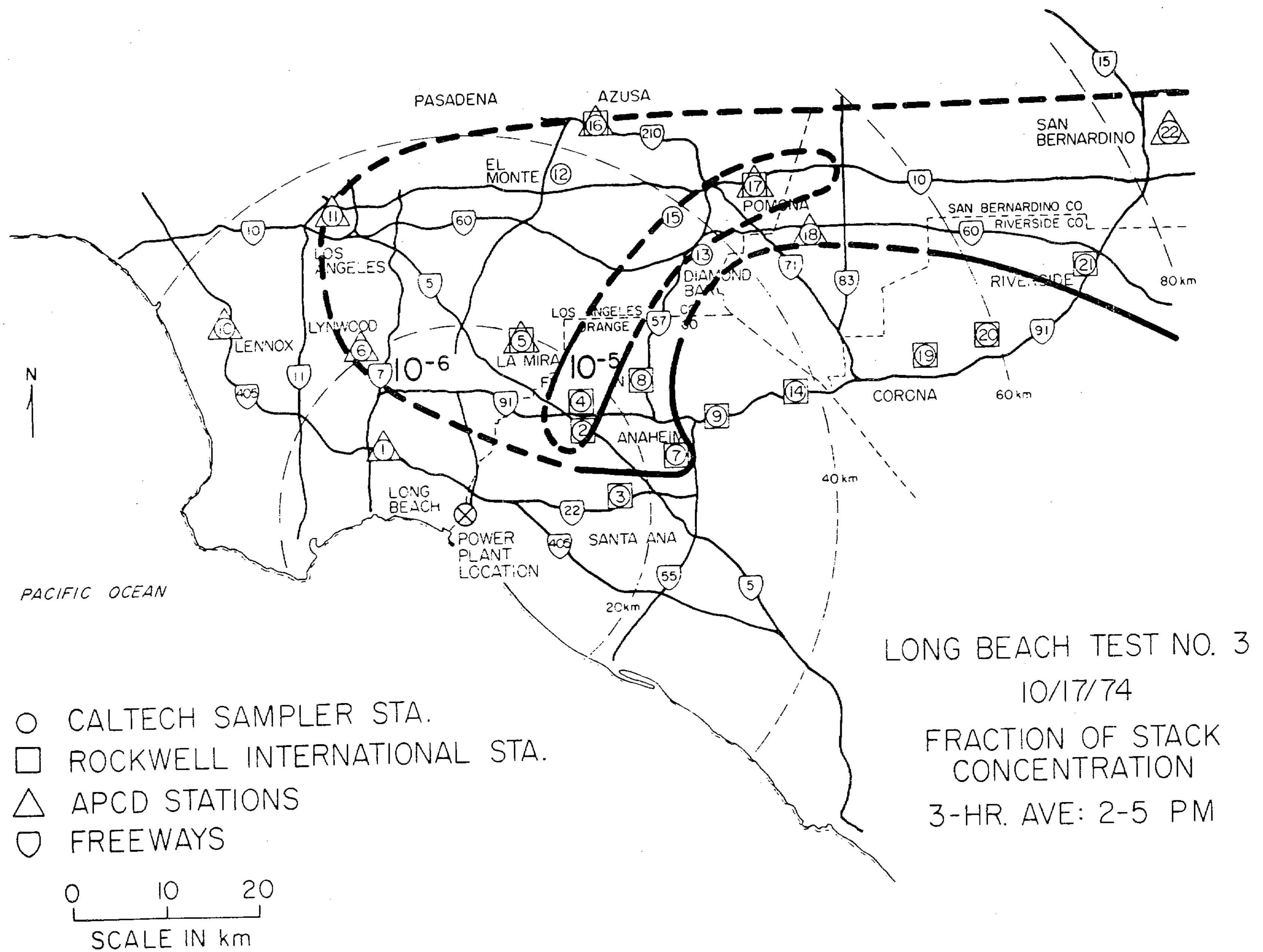

Figure 35. Three-hour averaged concentration isopleths for Long Beach Test No. 3: 2 p.m. to 5 p.m. (PST).

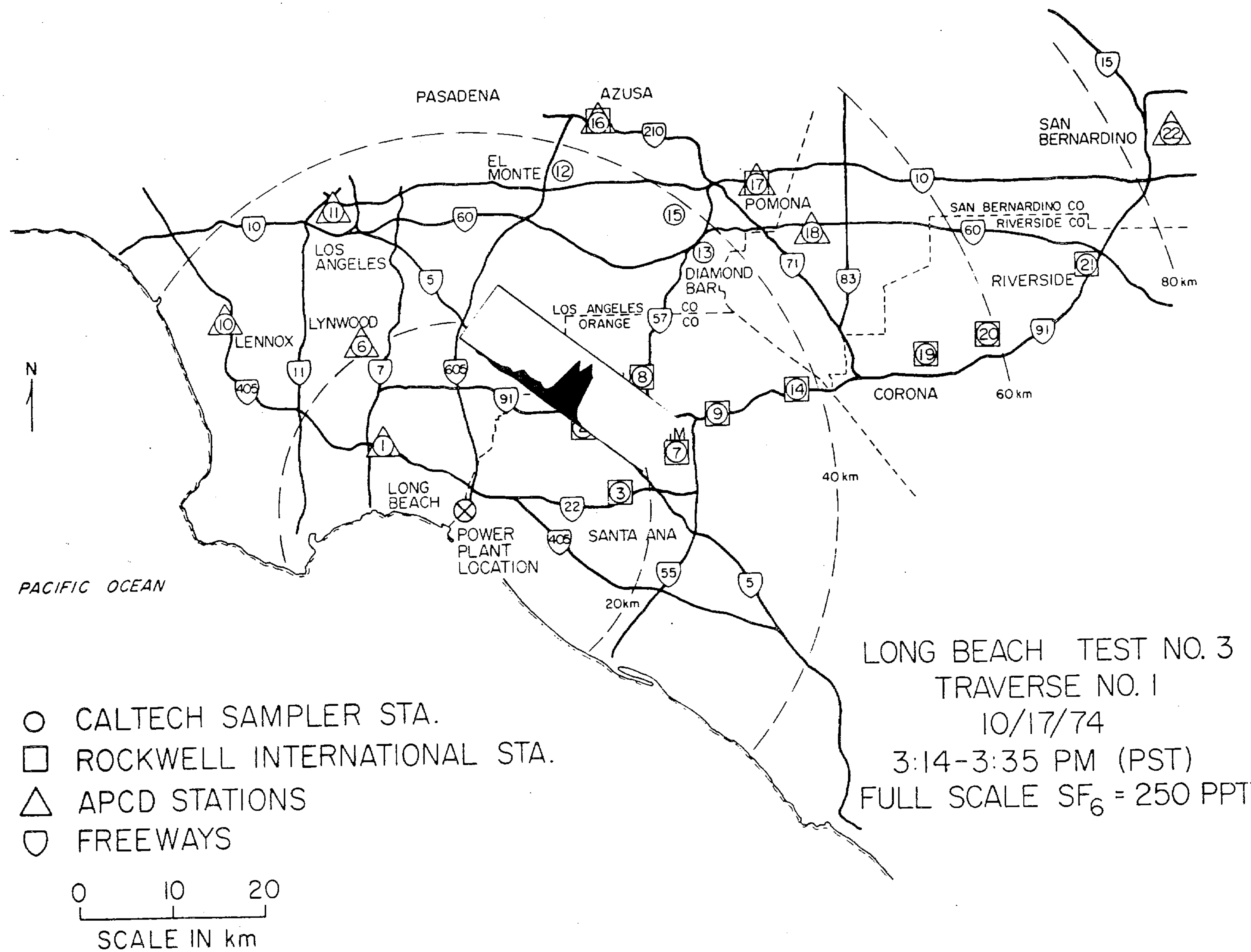

Figure 36. Automobile Traverse No. 1 for Long Beach Test No. 3.

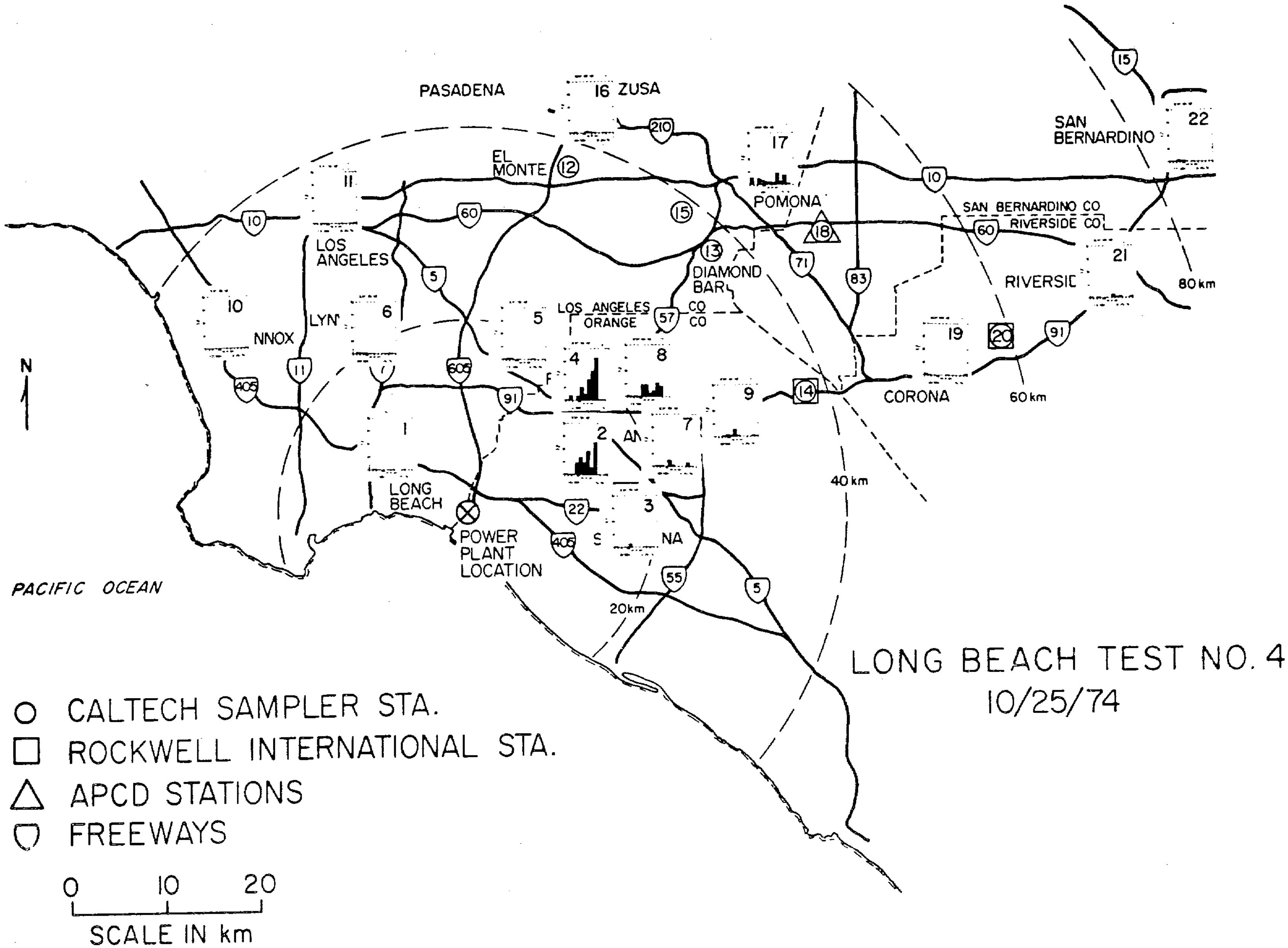

Figure 37. Overview of results for Long Beach Test No. 4; the SF_6 scale ranges from 0-200 ppt and the time scale ranges from 8 a.m. to 8 p.m. (PST).

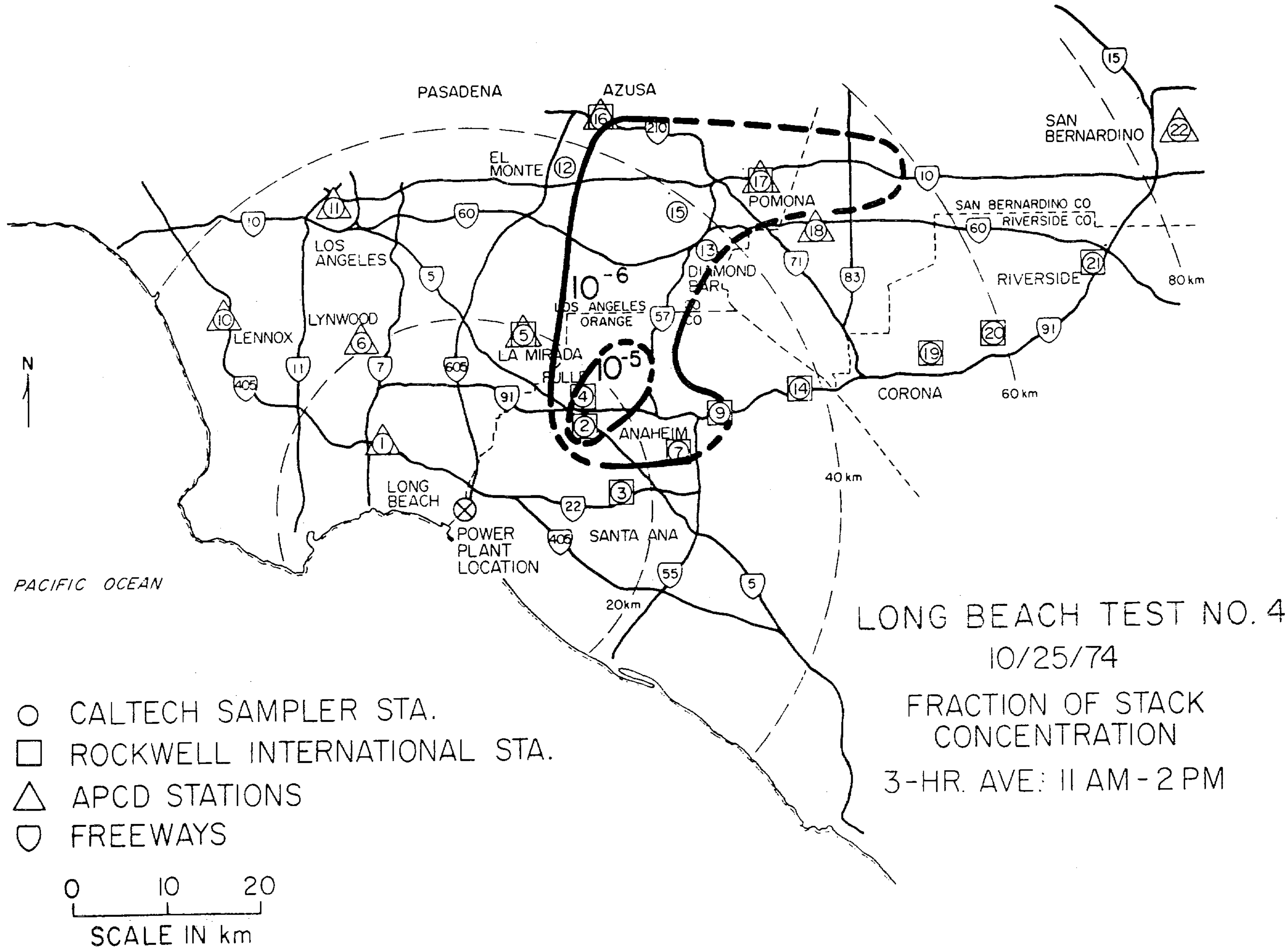

Figure 38. Three-hour averaged concentration isopleths for Long Beach Test No. 4: 11 a.m. to 2 p.m. (PST).

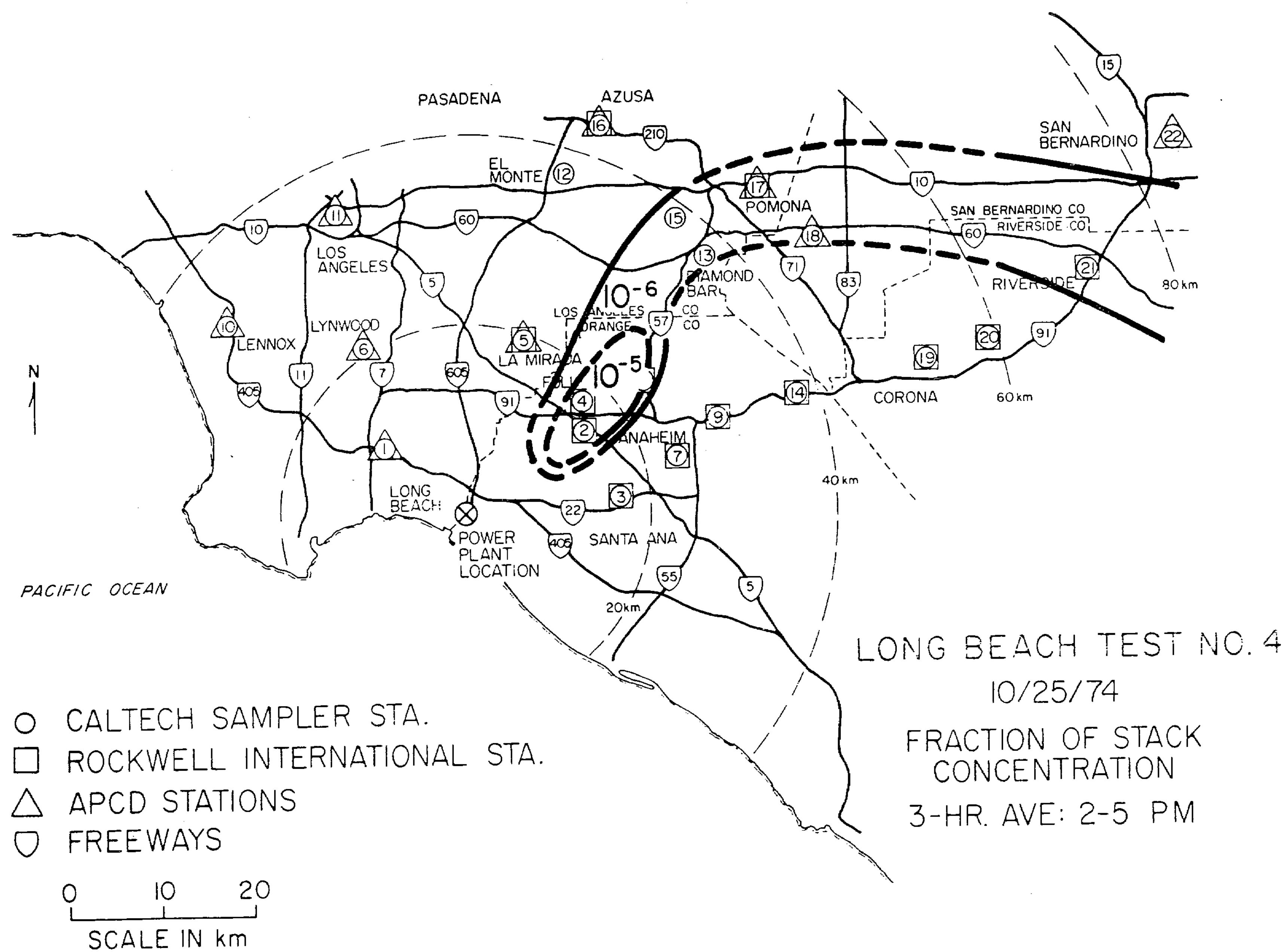

Figure 39. Three-hour averaged concentration isopleths for Long Beach Test No. 4: 2 p.m. to 5 p.m. (PST).

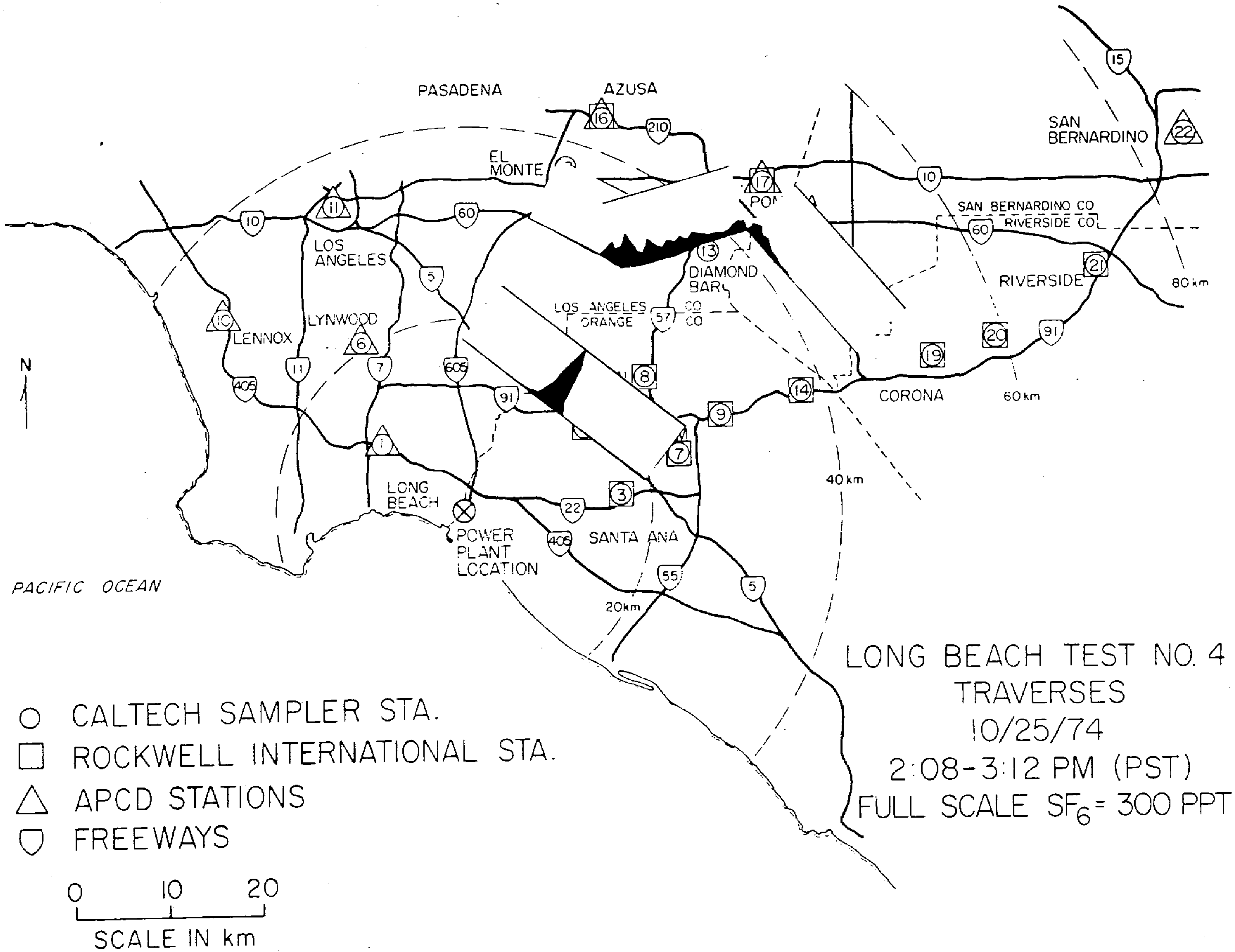

Figure 40. Automobile Traverses for Long Beach Test No. 4.

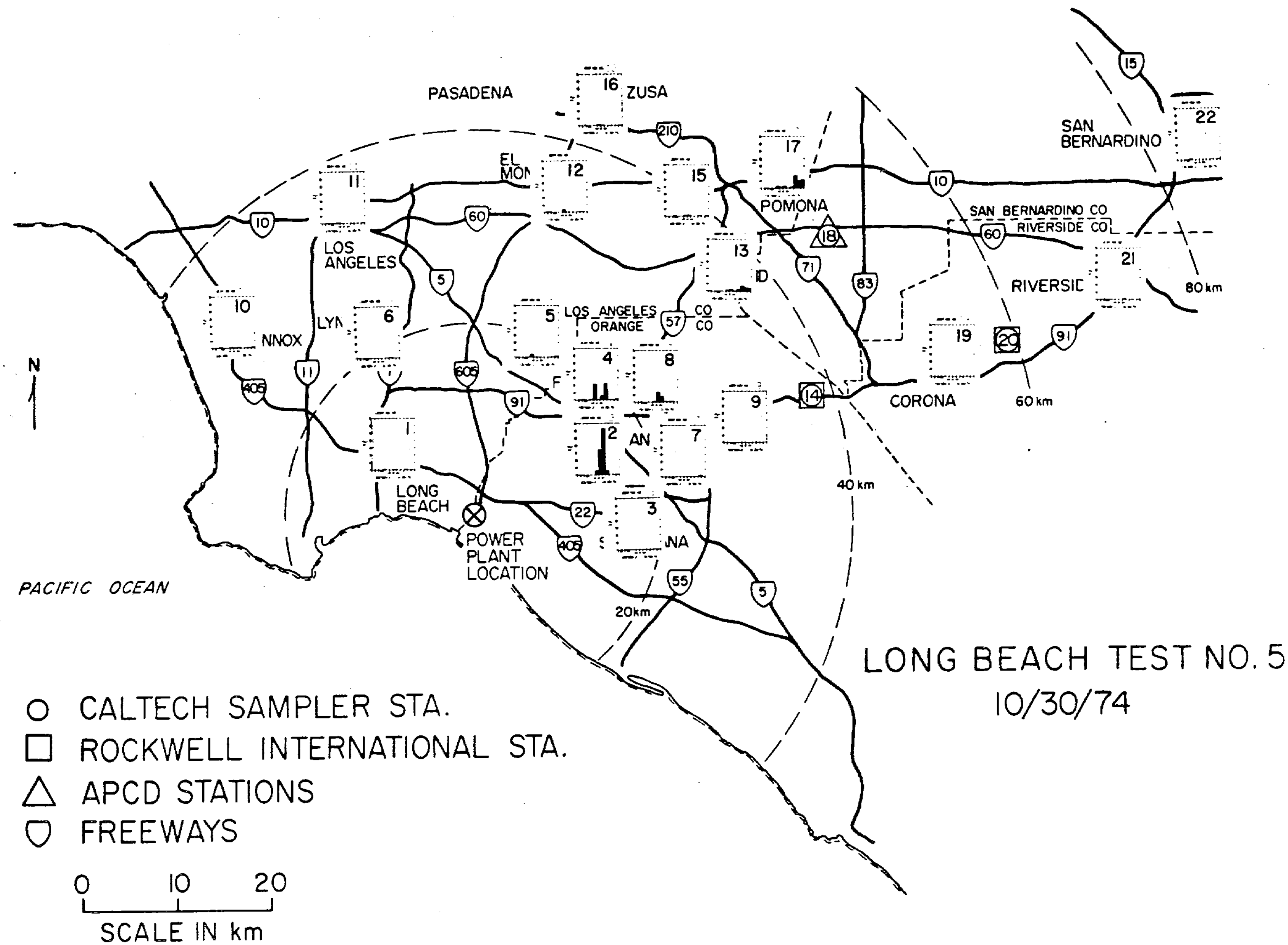

Figure 41. Overview of results for Long Beach Test No. 5; the SF_6 scale ranges from 0-350 ppt and the time scale ranges from 9 a.m. to 9 p.m. (PST).

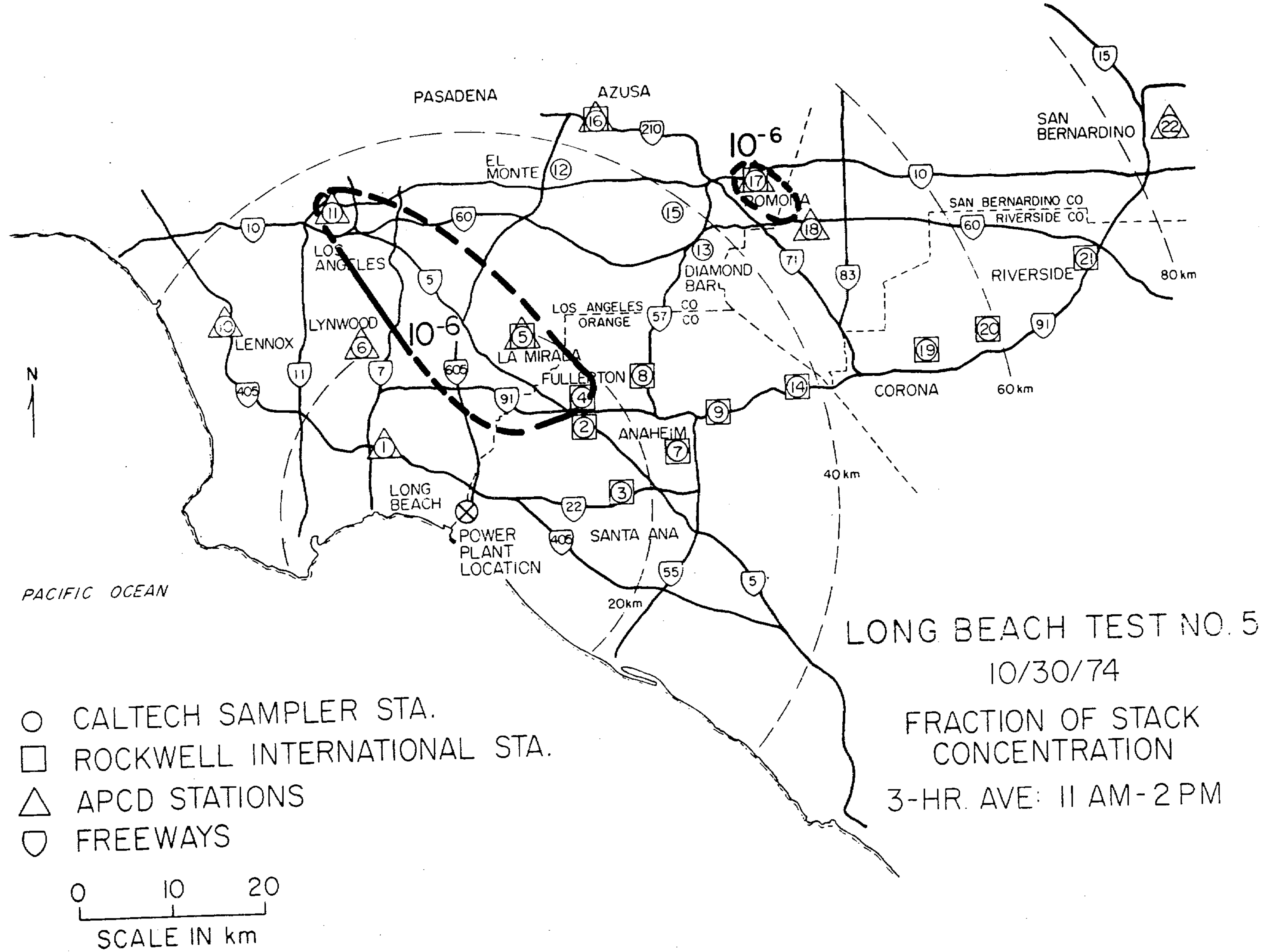

Figure 42. Three-hour averaged concentration isopleths for Long Beach Test No. 5: 11 a.m. to 2 p.m. (PST).

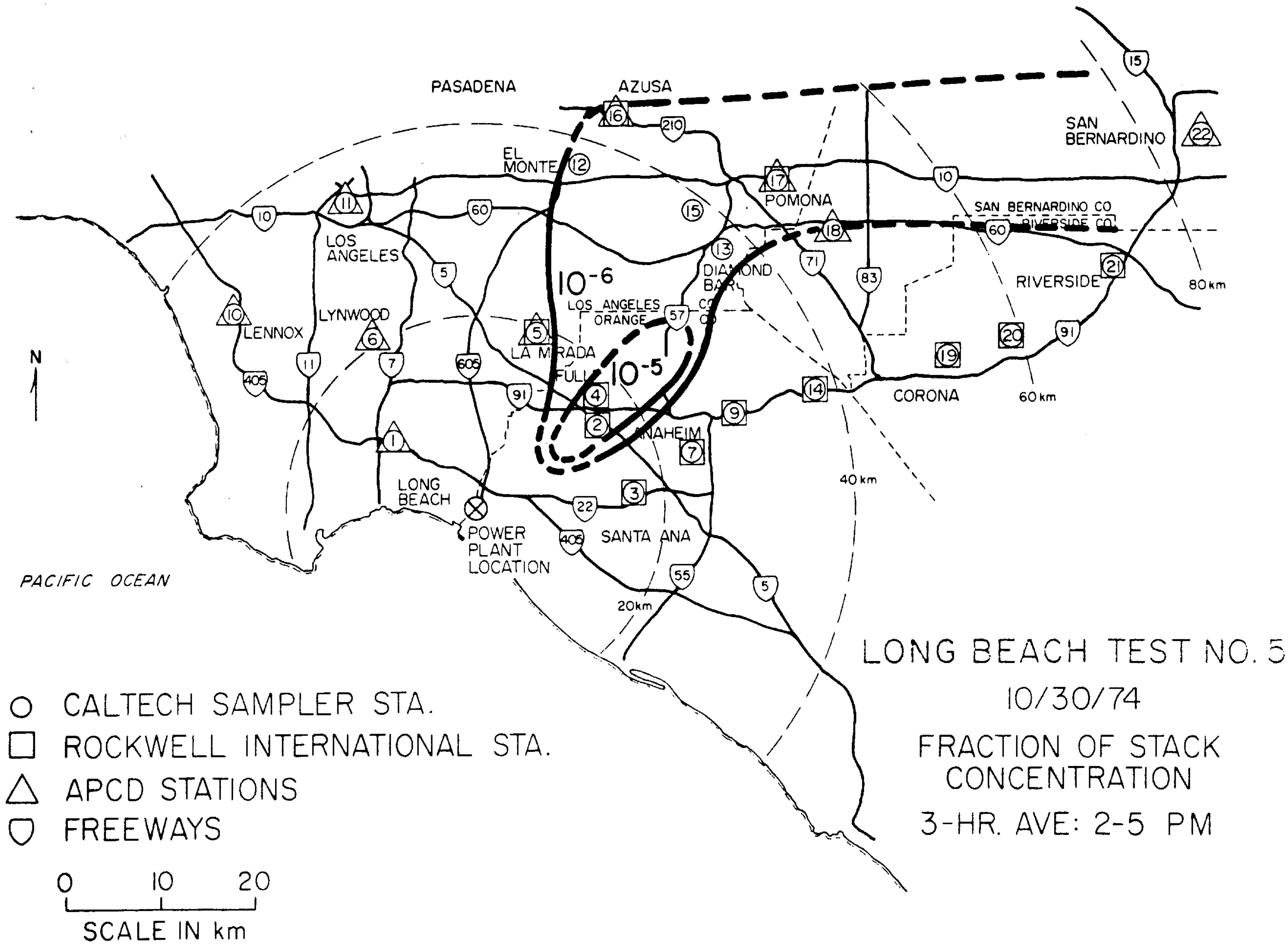

Figure 43. Three-hour averaged concentration isopleths for Long Beach Test No. 5: 2 p.m. to 5 p.m. (PST).

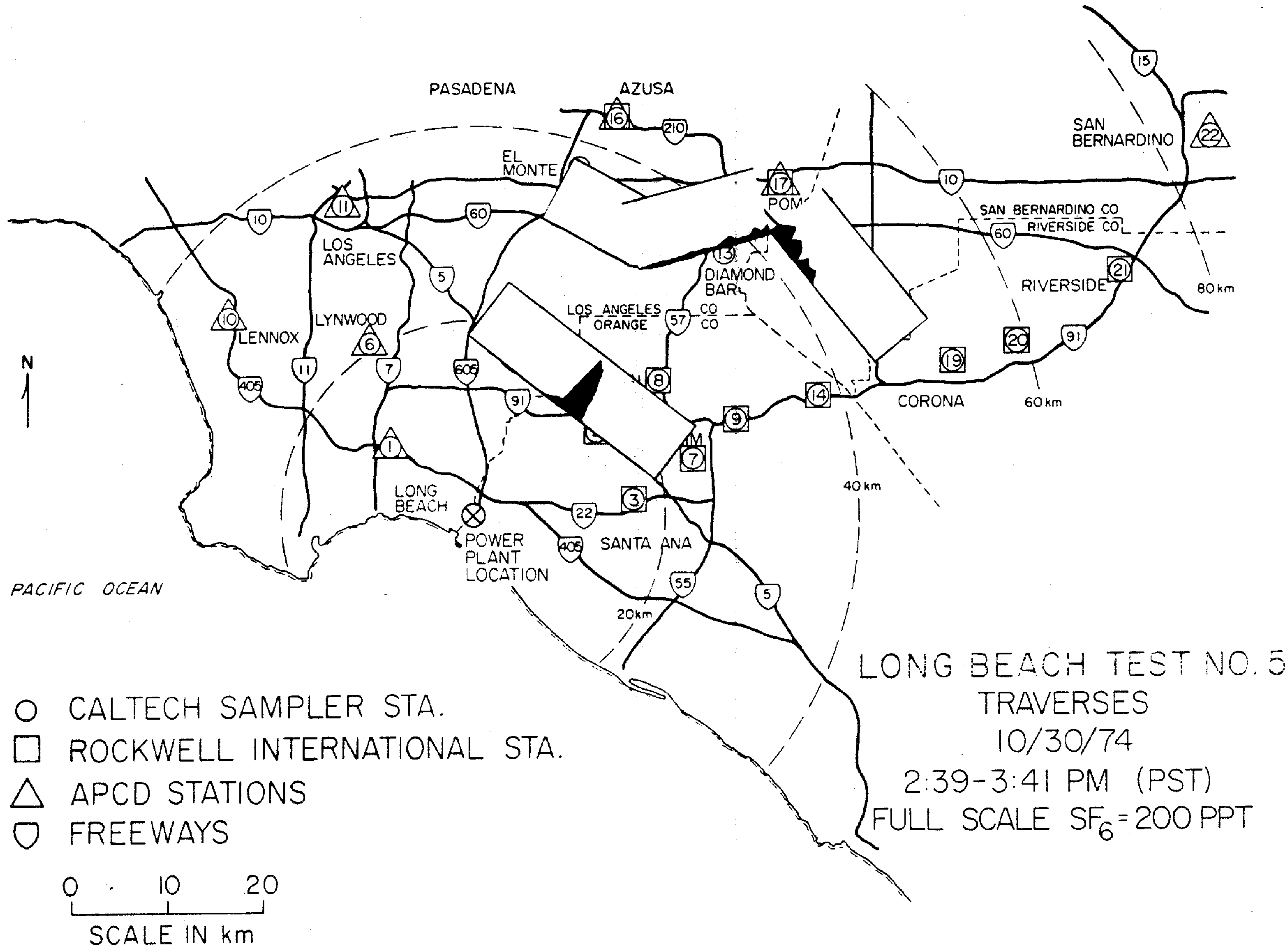

Figure 44. Automobile Traverses for Long Beach Test No. 5.

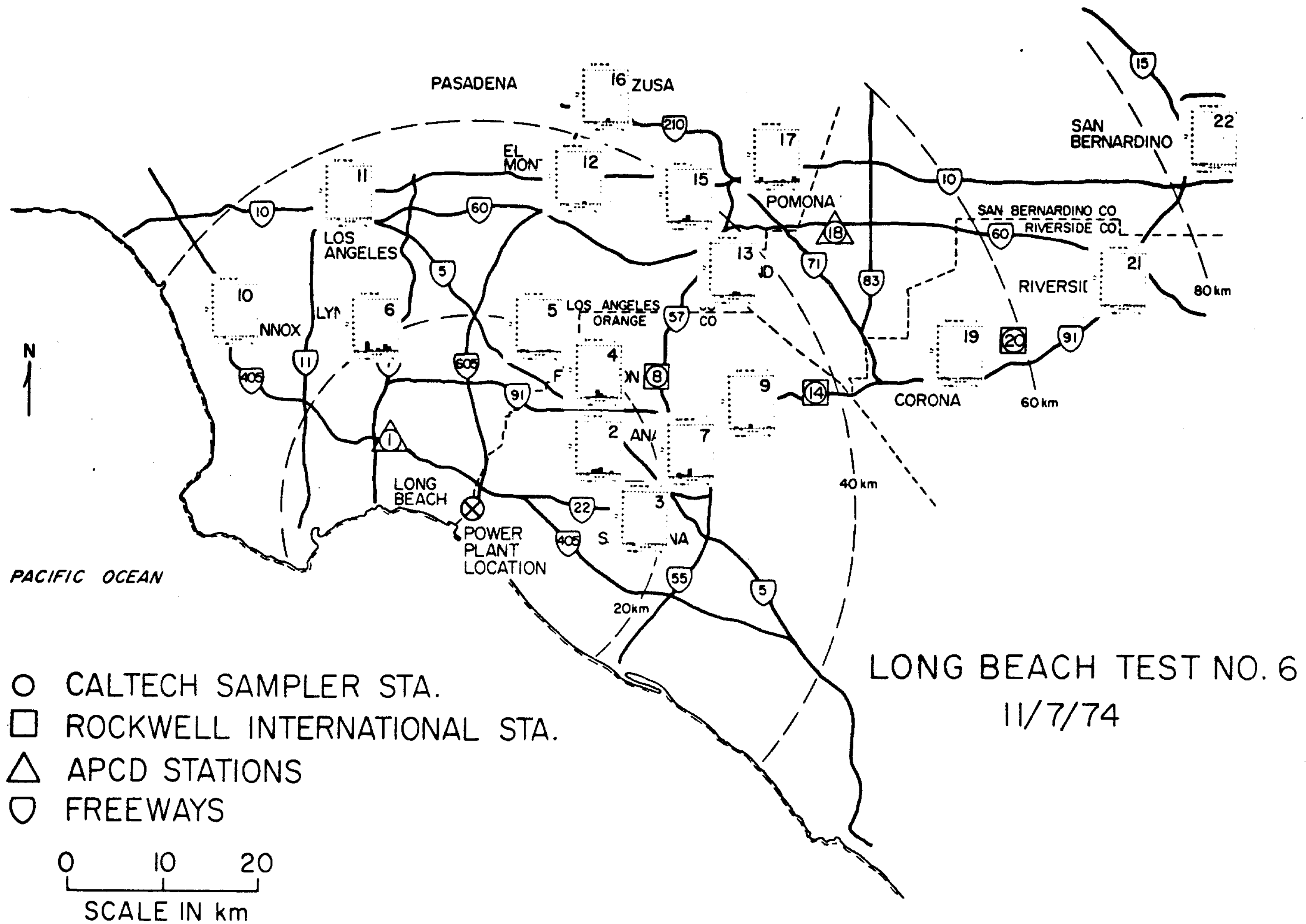

Figure 45. Overview of results for Long Beach Test No. 6; the SF_6 scale ranges from 0-900 ppt and the time scale ranges from 9 a.m. to 9 p.m. (PST).

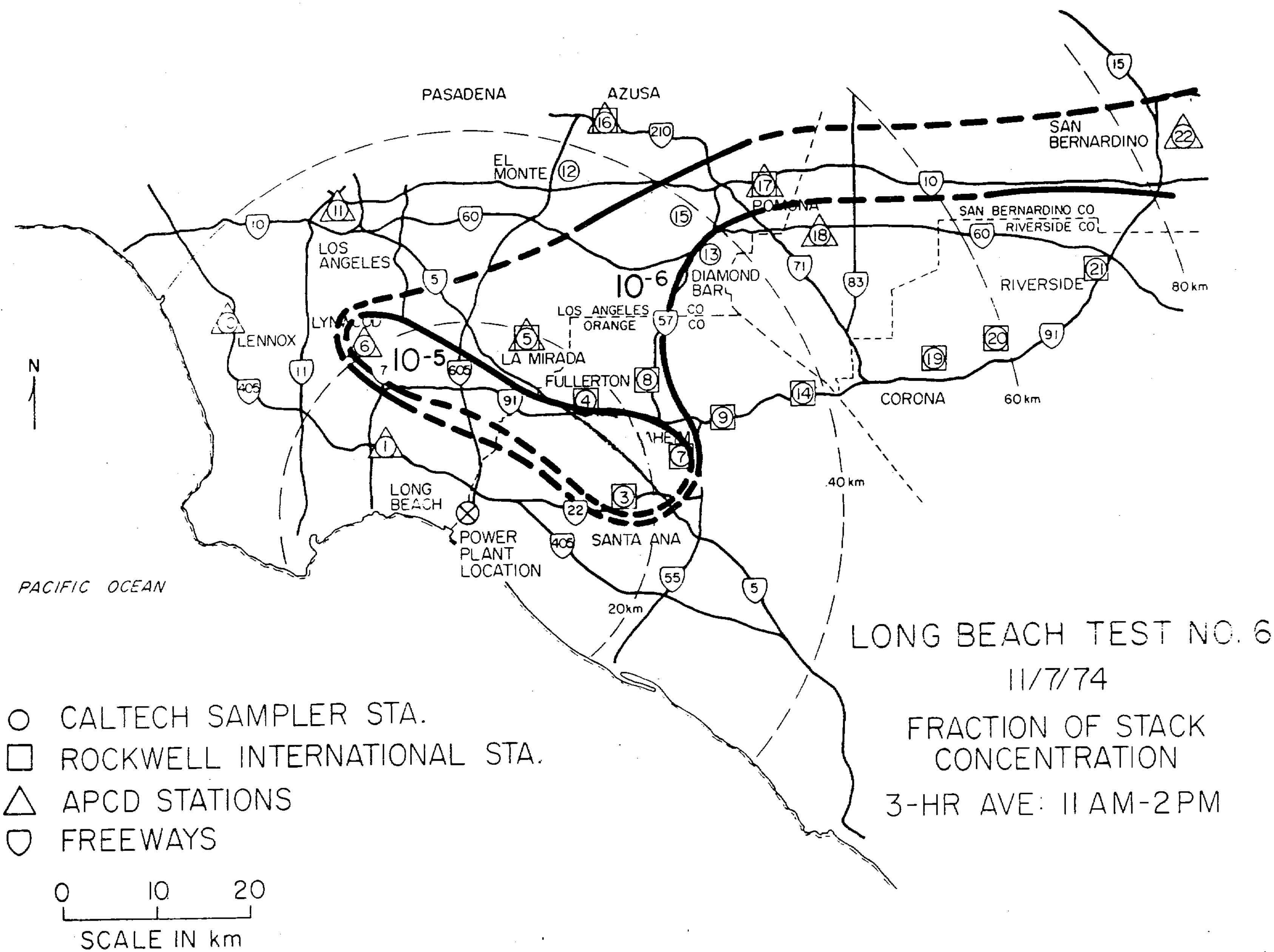

Figure 46. Three-hour averaged concentration isopleths for Long Beach Test No. 6: 11 a.m. to 2 p.m. (PST).

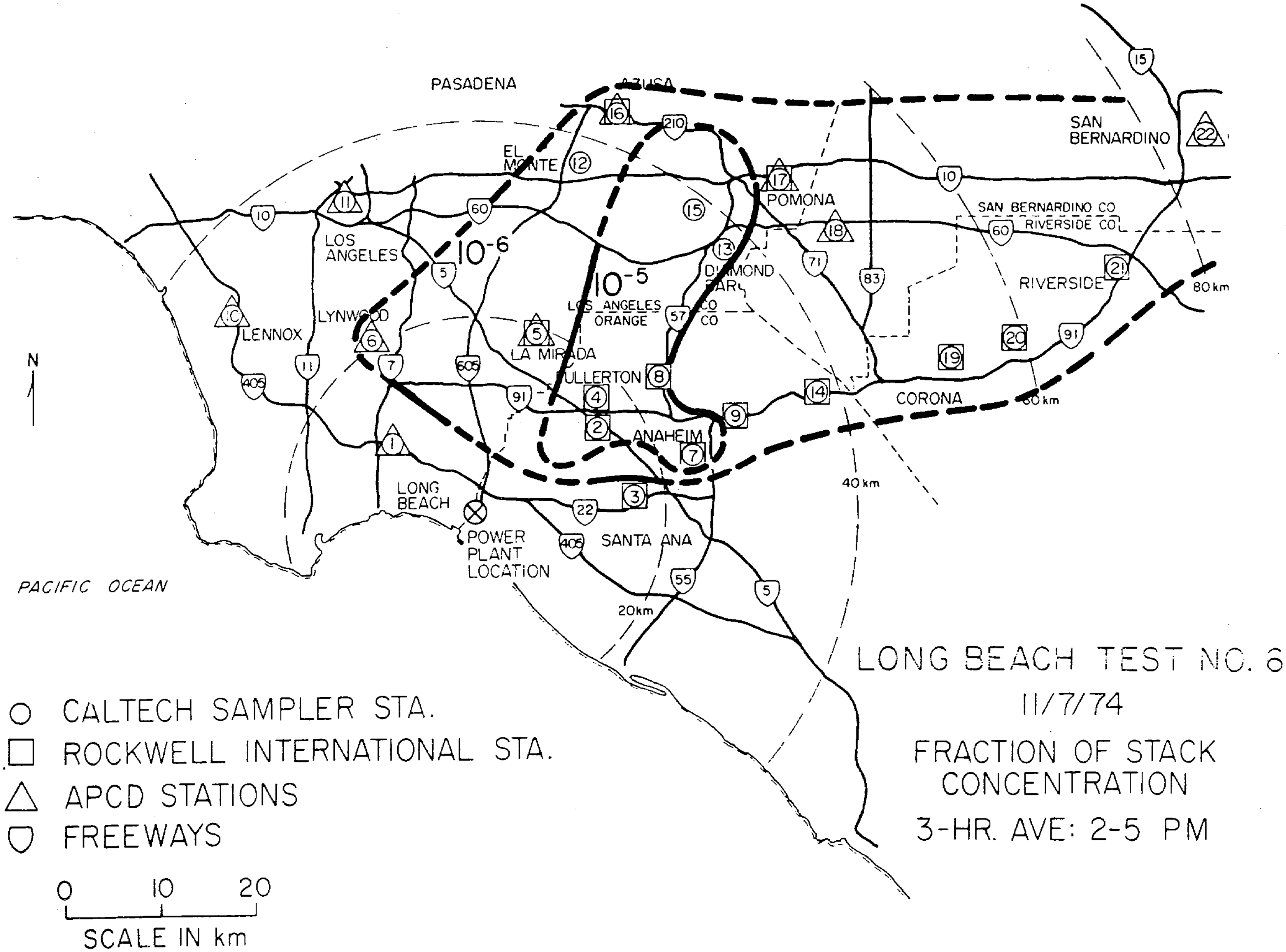

Figure 47. Three-hour averaged concentration isopleths for Long Beach Test No. 6: 2 p.m. to 5 p.m. (PST).

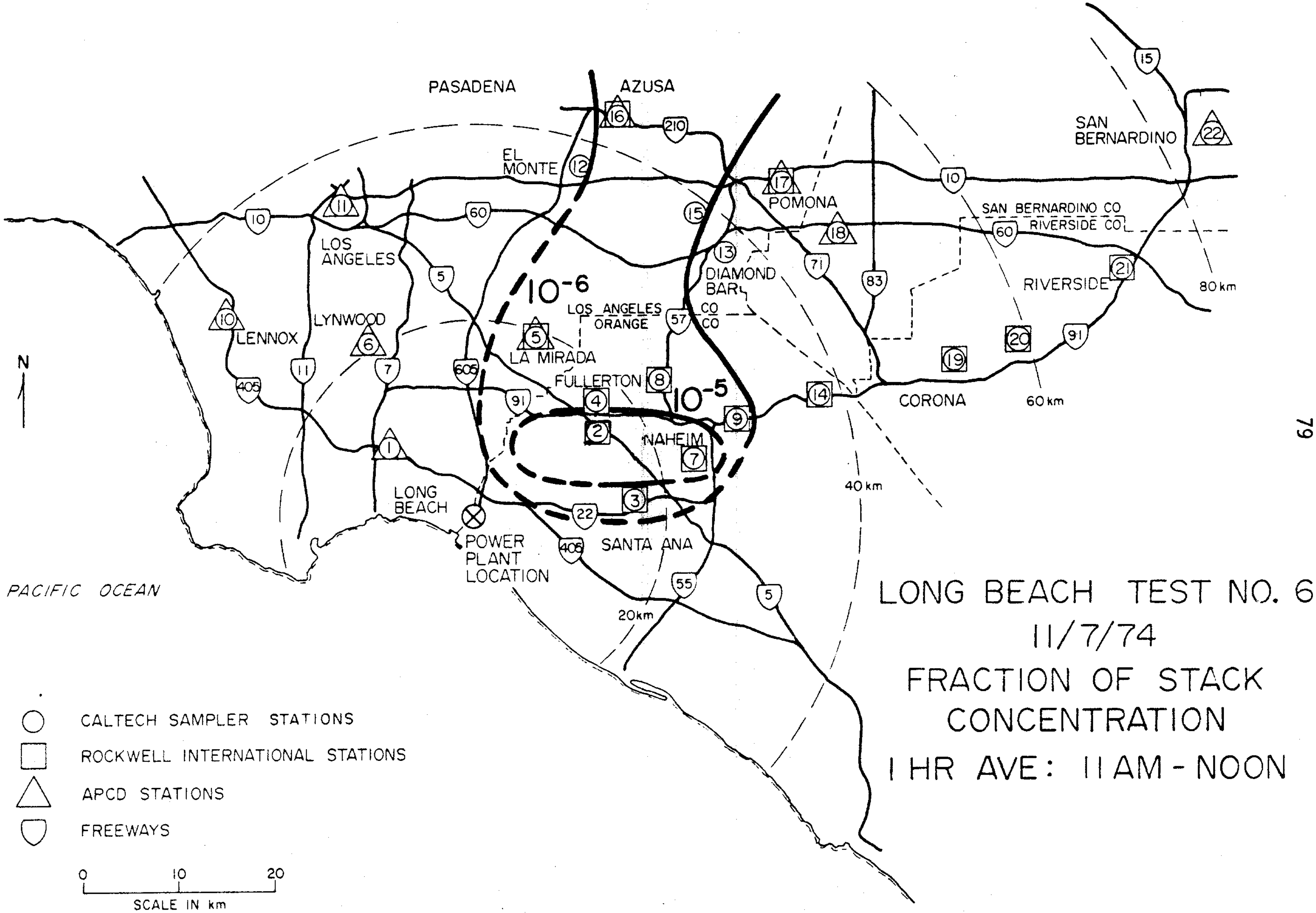

Figure 48. One-hour averaged concentration isopleths for Long Beach Test No. 6: 11 a.m. to 12 noon (PST).

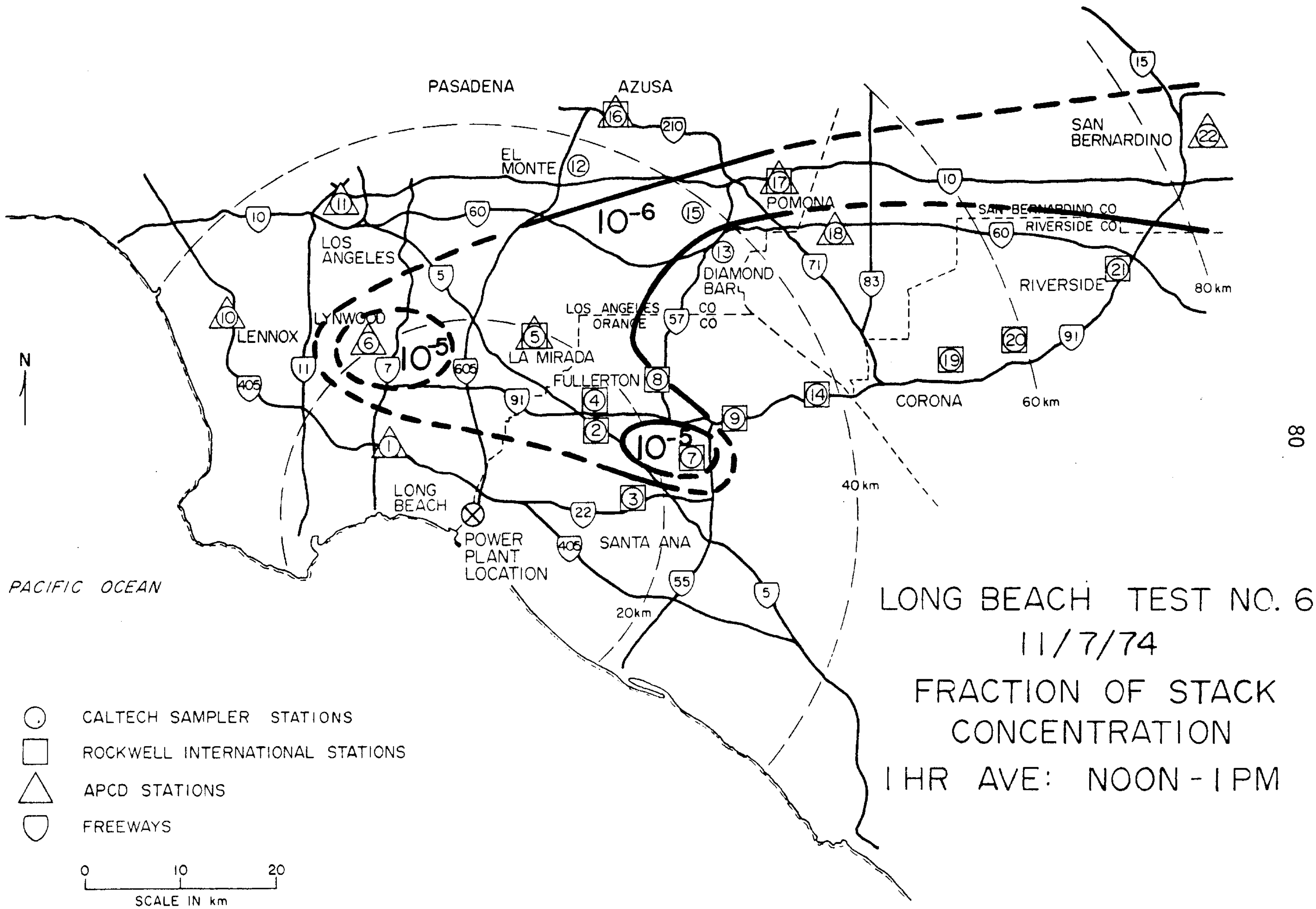

Figure 49. One-hour averaged concentration isopleths for Long Beach Test No. 6: 12 noon to 1 p.m. (PST).

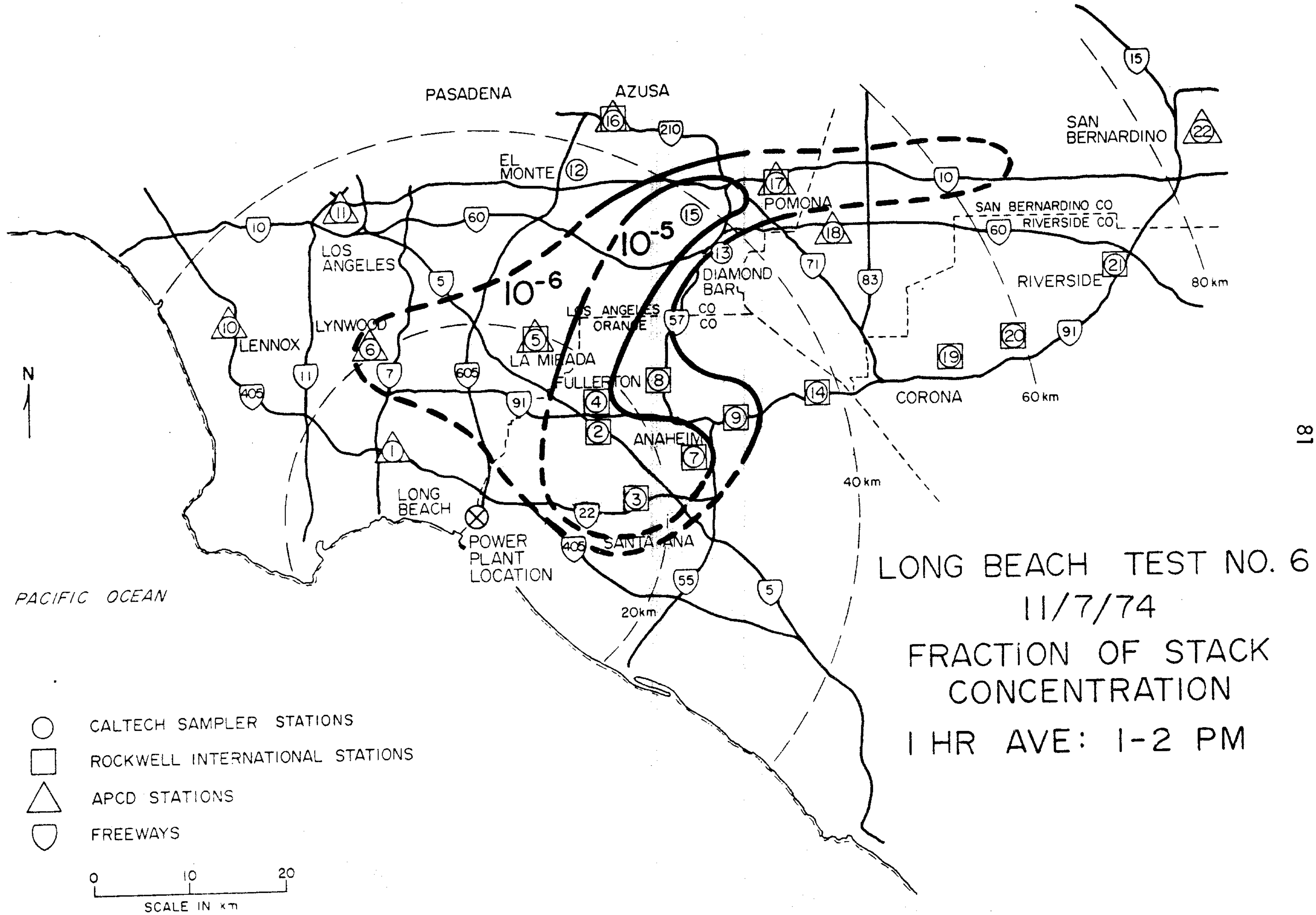

Figure 50. One-hour averaged concentration isopleths for Long Beach Test No. 6: 1 p.m. to 2 p.m. (PST).

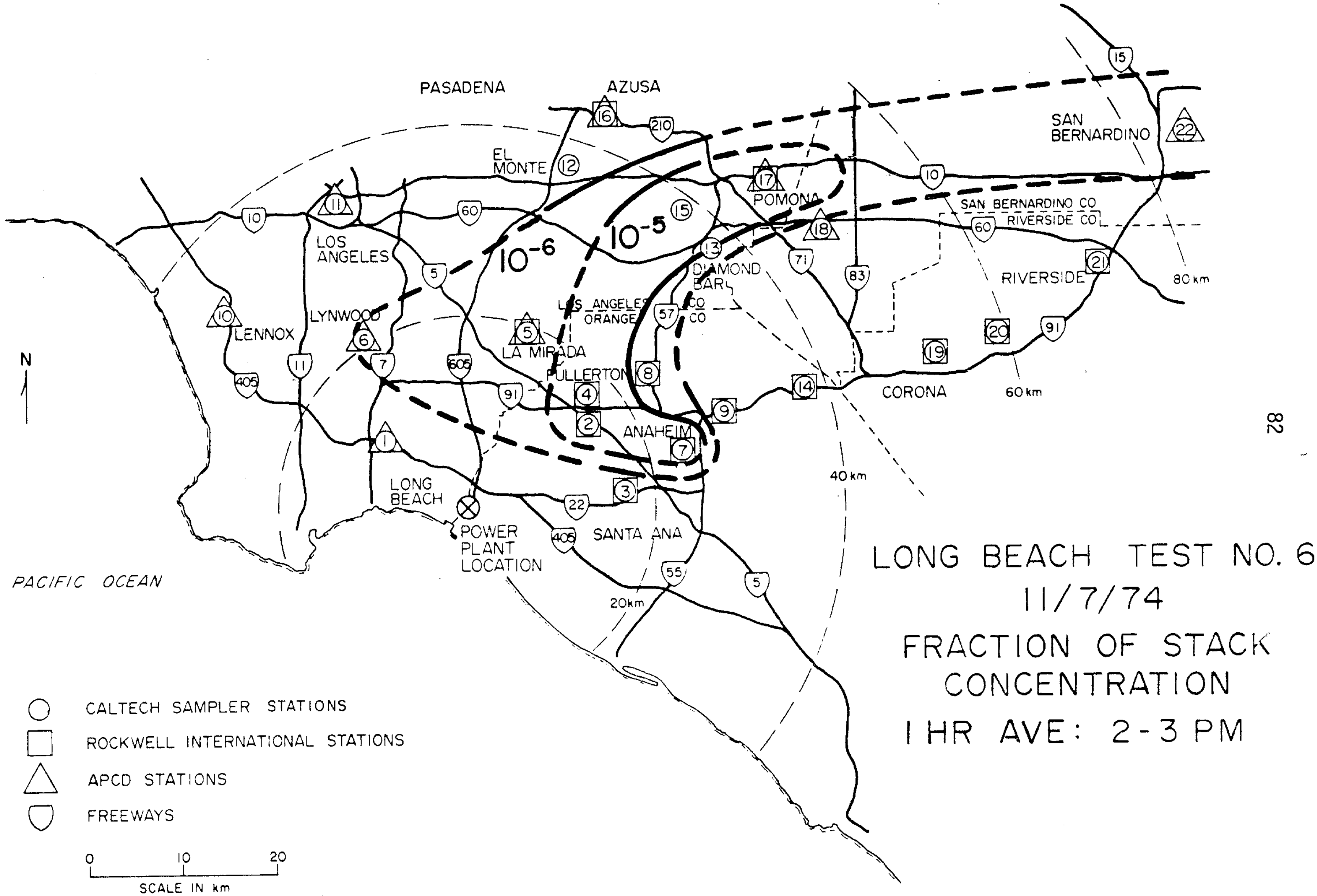

Figure 51. One-hour averaged concentration isopleths for Long Beach Test No. 6: 2 p.m. to 3 p.m. (PST).

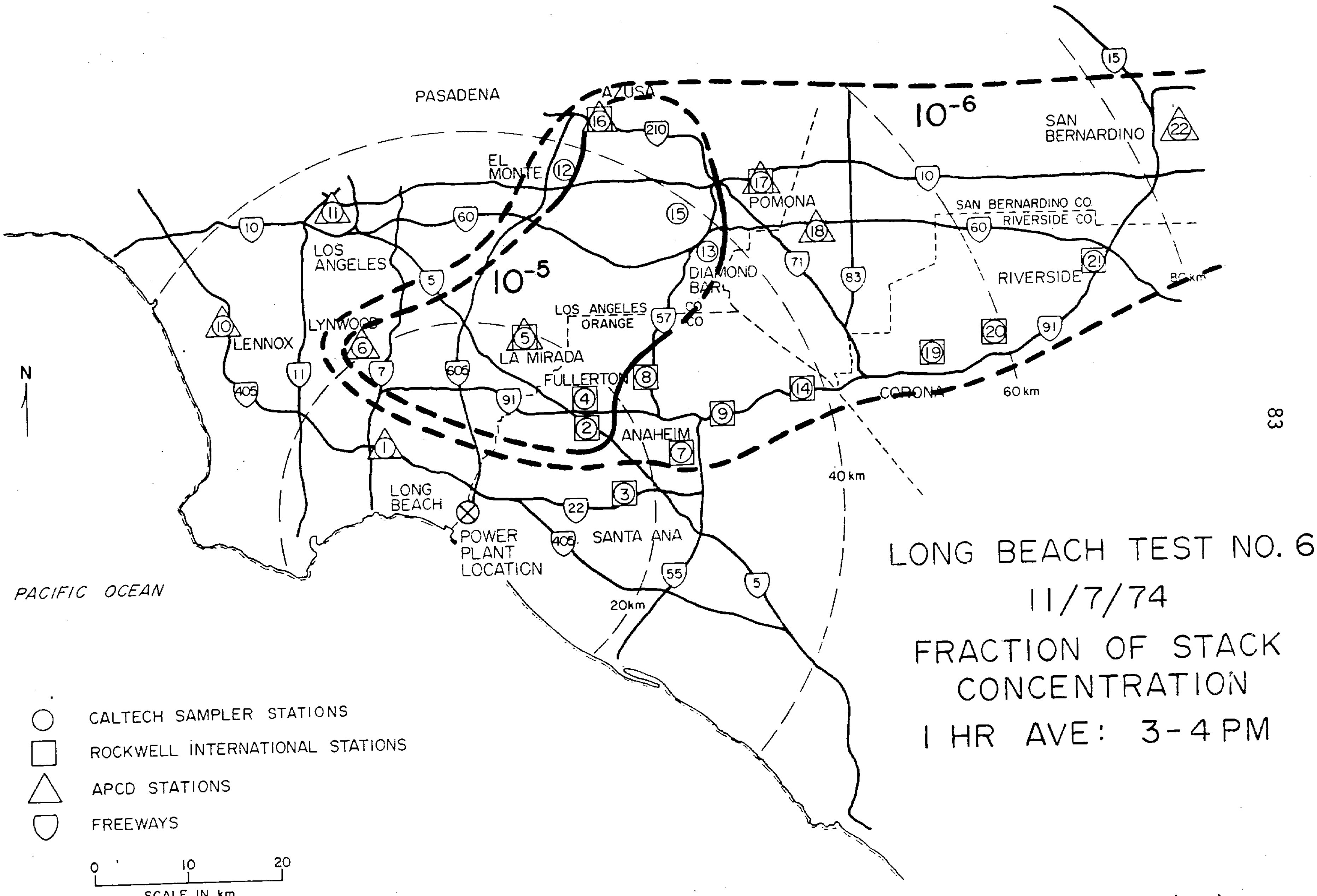

Figure 52. One-hour averaged concentration isopleths for Long Beach Test No. 6: 3 p.m. to 4 p.m. (PST).

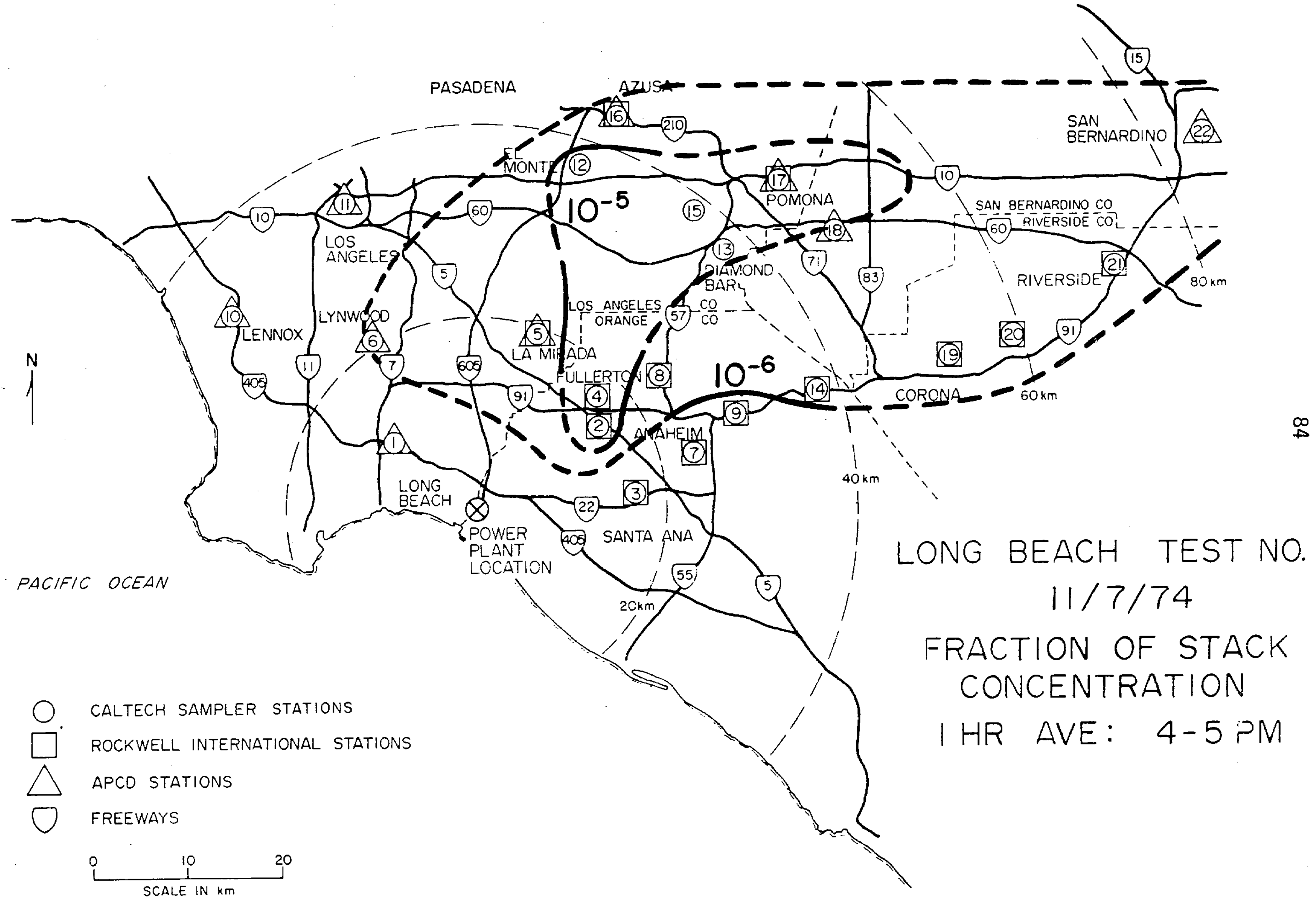

Figure 53. One-hour averaged concentration isopleths for Long Beach Test No. 6: 4 p.m. to 5 p.m. (PST).

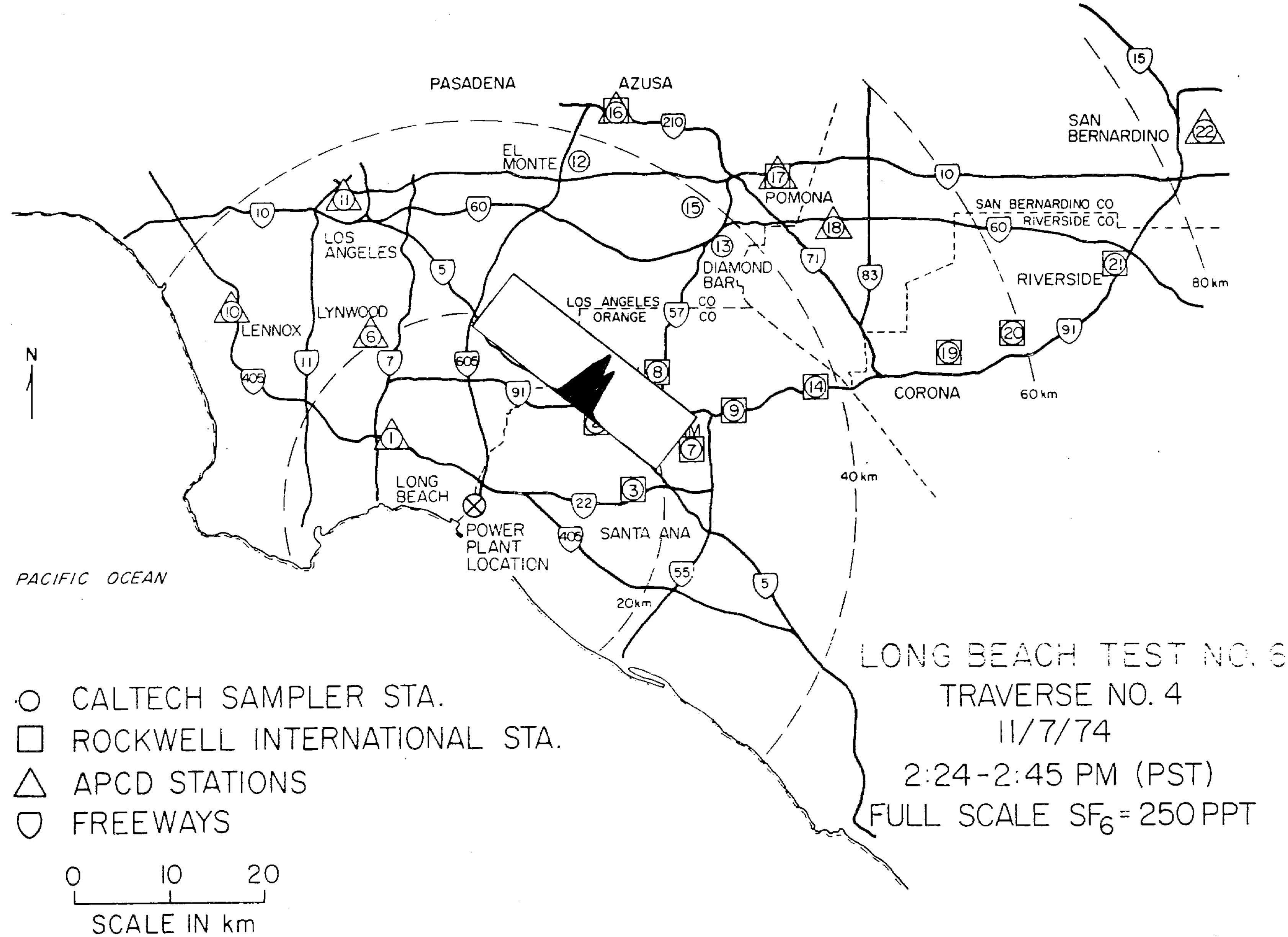

Figure 54. Automobile Traverse No. 4 for Long Beach Test No. 6.

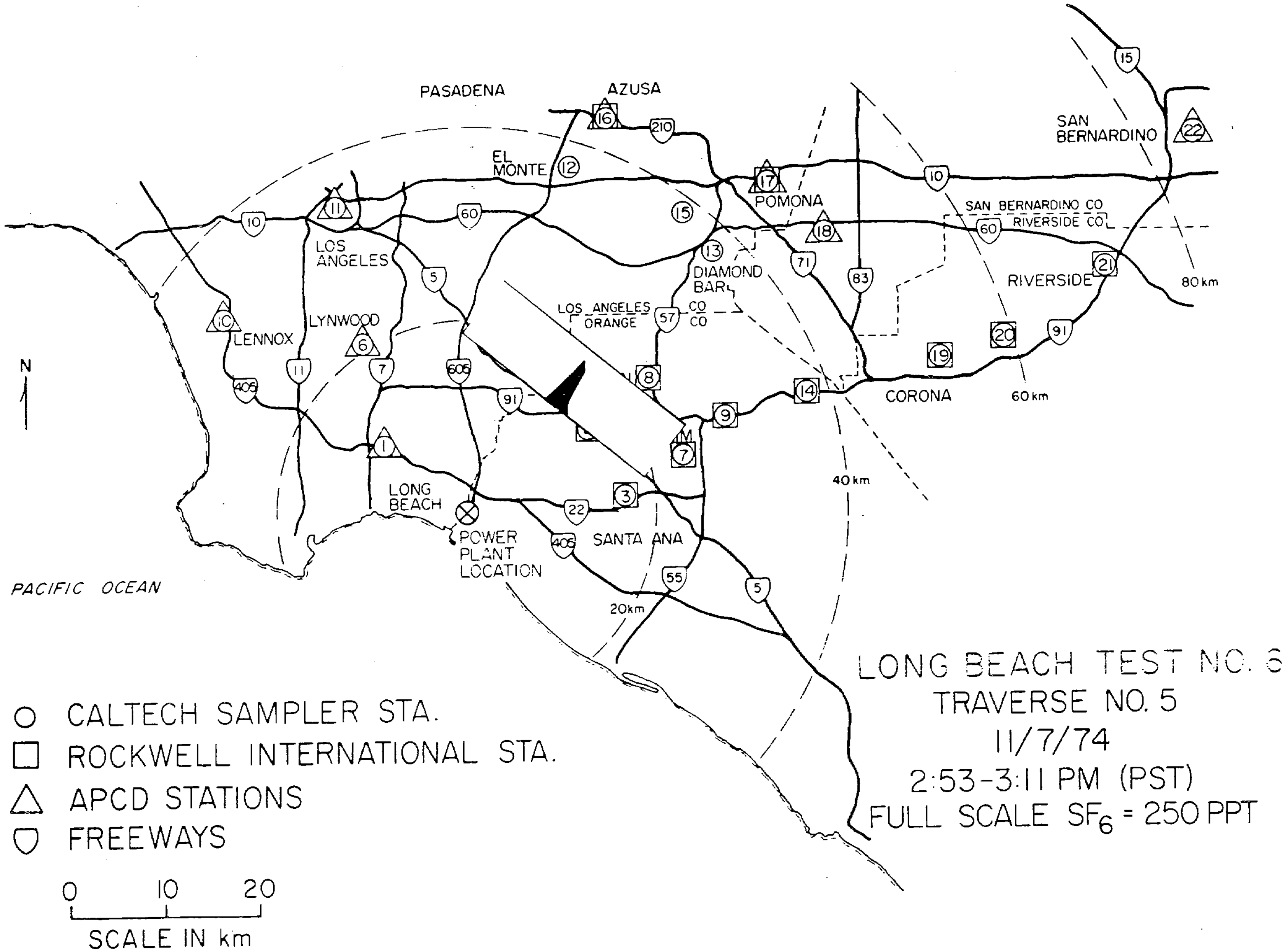

Figure 55. Automobile Traverse No. 5 for Long Beach Test No. 6.

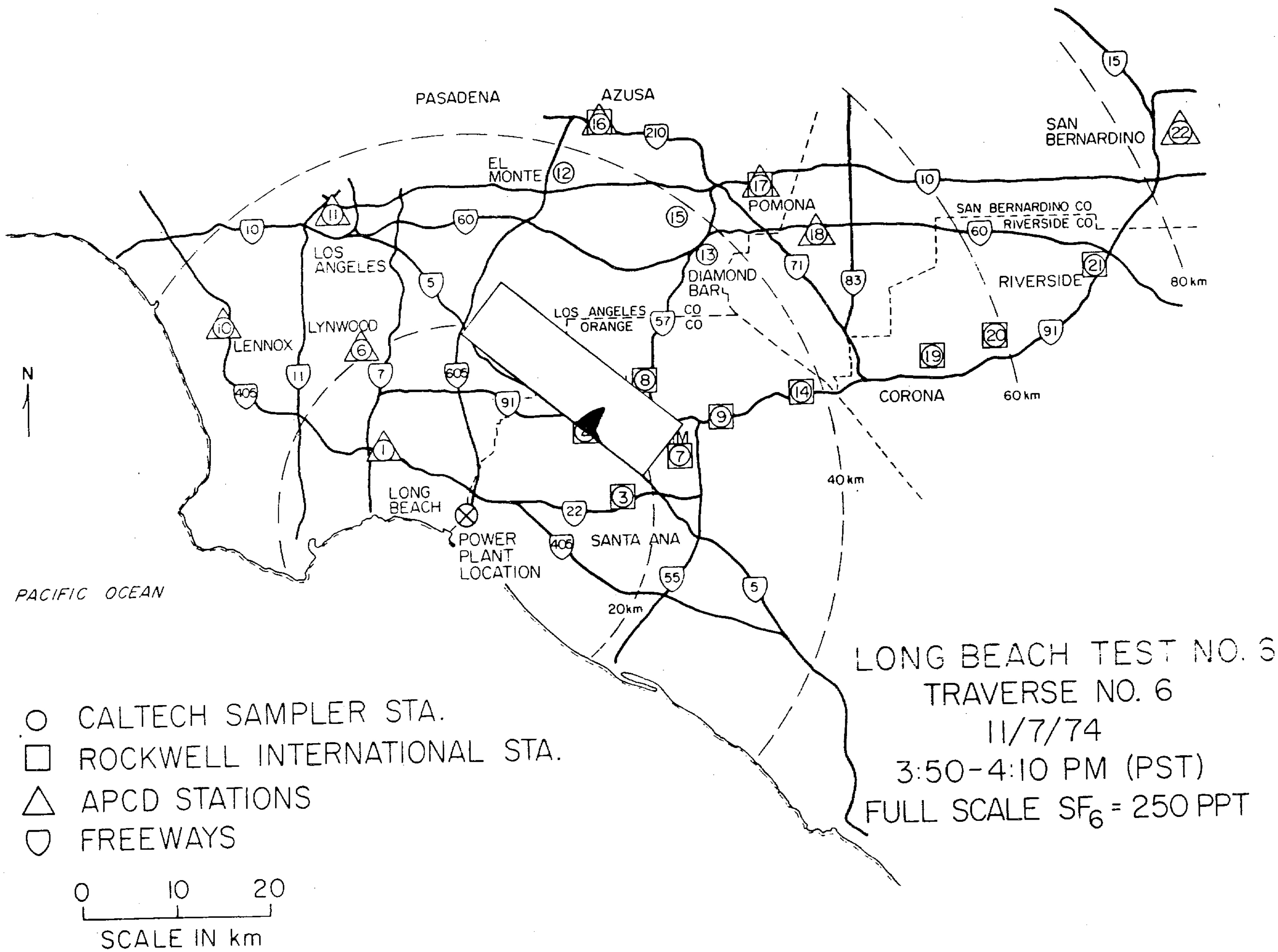

Figure 56. Automobile Traverse No. 6 for Long Beach Test No. 6.

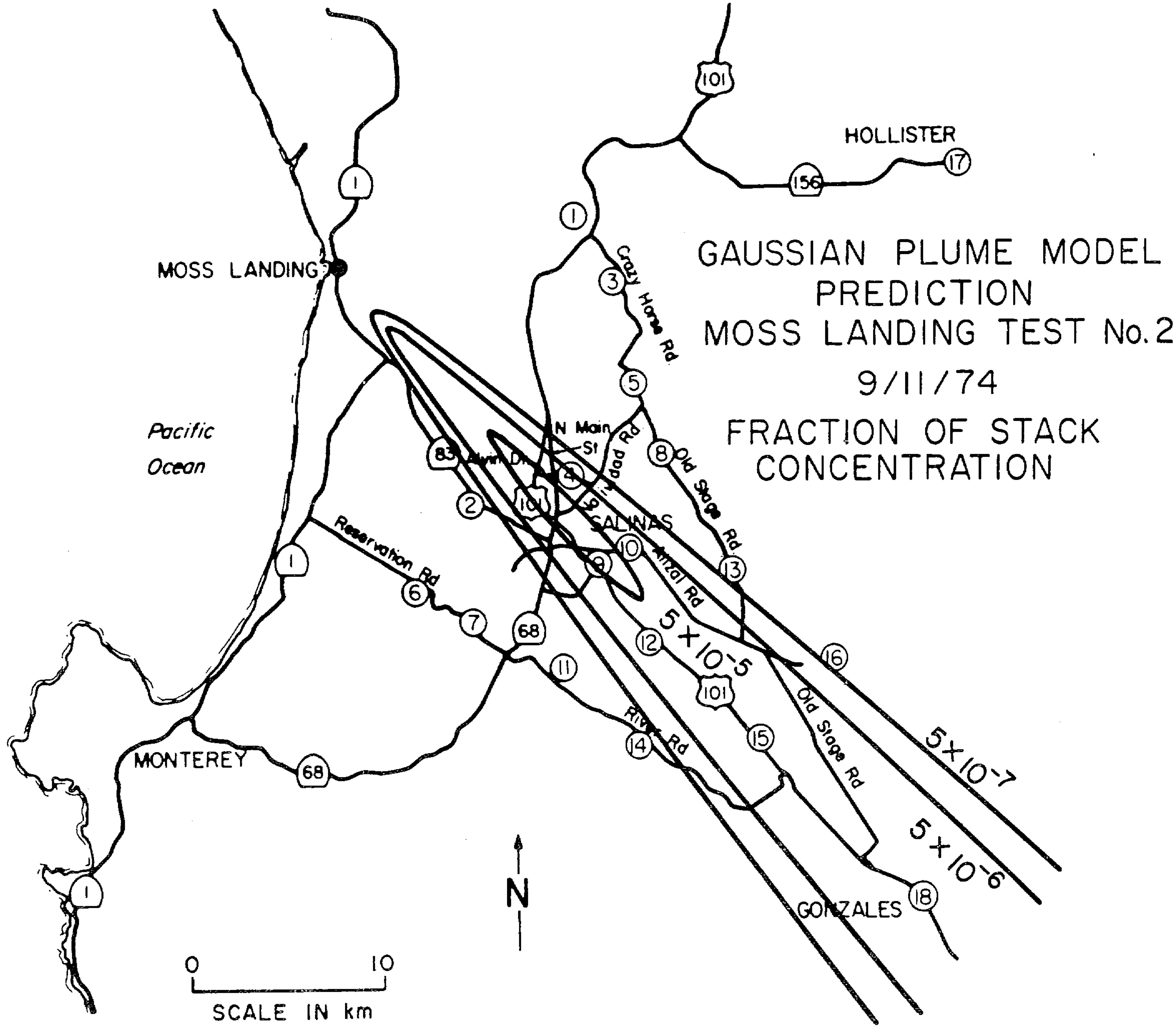

Figure 57. Gaussian plume model prediction for Moss Landing Test No. 2.

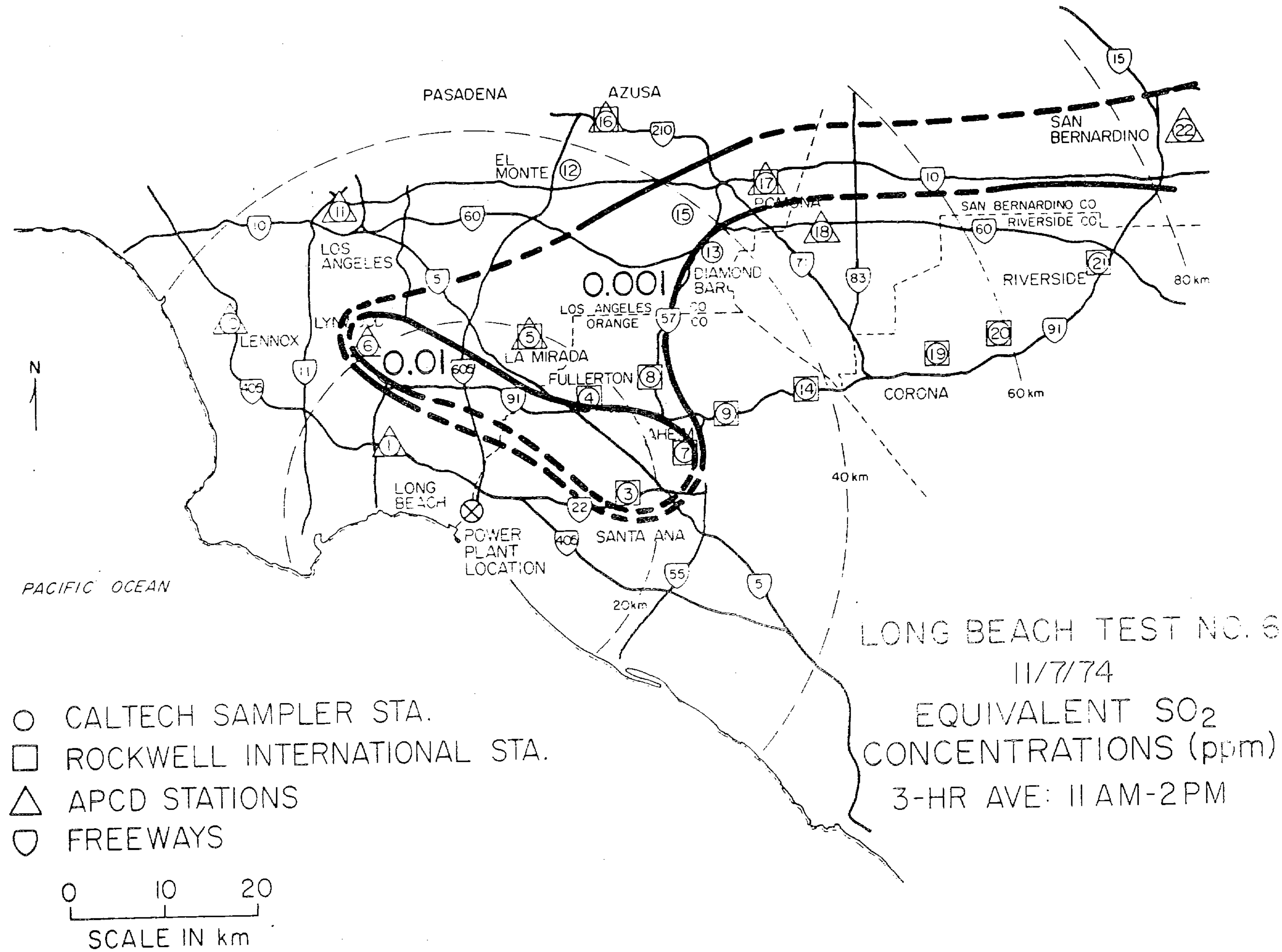

Figure 58. Three-hour averaged equivalent SO_2 concentration isopleths for Long Beach Test No. 6: 11 a.m. to 2 p.m. (PST).

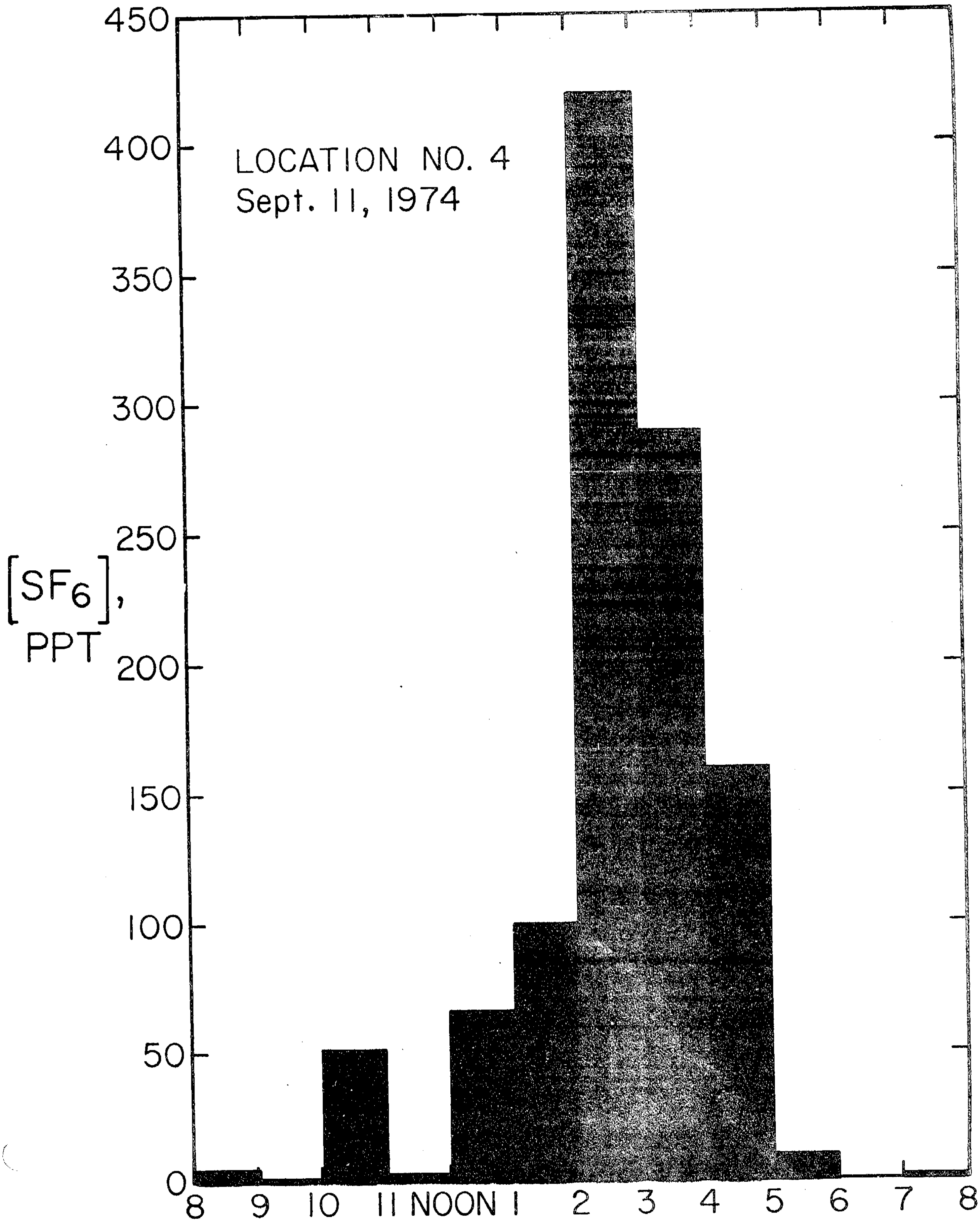

Figure 59. Close-up of bar graph for Location No. 4, Moss Landing Test No. 2.

APPENDICES

APPENDIX A-1

Testing of Automatic Sequential Air Sampler

Description of Test

An automatic sequential sampling unit, consisting of 12 motor-driven syringes which each sampled for a one-hour duration, was tested for three important factors: reproducibility or precision; accuracy; and leakage when exposed to an outdoor environment. On July 18, 1974, a test concentration function of sulfur hexafluoride was released in a small room; the concentration function included a step increase and two different decrease rates. The sequential sampler was adjusted so that all 12 syringes operated simultaneously during the test function. A fan was used to provide well-mixing in the vicinity of the sampler.

Reproducibility

Six of the syringes were analyzed immediately at the conclusion of the sampling time. The results were as follows:

Syringe Position	[SF_6]
#1	1.71×10^{-8}
#3	1.70×10^{-8}
#5	1.69×10^{-8}
#7	1.69×10^{-8}
#9	1.68×10^{-8}
#11	1.67×10^{-8}

The average concentration was 1.69×10^{-8}. The reproducibility or precision, expressed as one standard deviation, was excellent: ± 1.0%.

Accuracy

To determine the accuracy of the sampling unit, the test concentration function was integrated over the sampling period, T:

$$c_{ave} = \frac{1}{T}\int_0^T c\,dt \qquad \text{(A-1)}$$

The sampling period, T, in the experiment was 60 minutes. If the sampling unit operated uniformly over the hour period, and no back diffusion occurred, the syringes should contain an average concentration described by equation (A-1). The test concentration function was integrated over the sampling period by using simple exponential decay functions. The resulting average concentration, using equation (A-1), was 1.71×10^{-8}. This value is within 1% of the average concentration recorded by the six syringes which were analyzed immediately. Thus, the accuracy, in addition to the reproducibility, was excellent. The syringes apparently operated uniformly over the hour period with no back diffusion occurring.

Leakage

Six of the syringes were placed on a rooftop overnight to test the closing mechanism of the sampling unit. They were analyzed the following day after 19.5 hours in an outdoor environment. The results were as follows:

Syringe Position	$[SF_6]$
#2	1.56×10^{-8}
#4	1.69×10^{-8}
#6	1.69×10^{-8}
#8	1.68×10^{-8}
#10	1.58×10^{-8}
#12	1.66×10^{-8}

The average concentration was 1.64×10^{-8}, which is approximately 4% lower than the accurate integrated concentration from equation (A-1). The reproducibility or precision, expressed as one standard deviation, was ± 3.5%--not as good as the precision of the six samples analyzed immediately. Apparently a small amount of leakage had taken place over the 19.5 hours outdoors; the leakage was most noticeable in syringes #2 and #10.

Conclusions

When samples were analyzed immediately, the reproducibility and accuracy of the sequential sampler were both excellent, within ± 1%. The syringes apparently operated uniformly over the hour period with no back diffusion occurring. When samples were analyzed after 19.5 hours outdoors, a small amount of leakage occurred, reducing the reproducibility and accuracy to ± 4%.

APPENDIX A-2

Discussion of Chromatograph Calibrations

Calibration of the four chromatographs was accomplished by means of a well-mixed exponential dilution system. Typical calibration curves for the four chromatographs (designated by Y1, Y2, Z1, and Z2) are shown in Figures 8-11. Calibrations were made before the Moss Landing tests (8/31/74), after the Moss Landing tests (9/17/74) and after the Los Angeles area tests (11/20/74). The slopes (KF factors) of the linear range of the calibration curves are listed below in Table A-1. It should be noted that all the SF_6 data points listed in Appendices A-4, A-7, and A-8 fell within the linear region.

TABLE A-1

Results of SF_6 Calibrations

Chromatograph	8/31/74	KF Factor* 9/17/74	11/20/74
Y1	253	287	181
Y2	158	164	173
Z1	219	232	191
Z2	168	212	194

*Ratio of integrator area (μV-sec) to SF_6 concentration (ppt) in the linear range.

The original 8/31/74 calibration was used to calculate all the SF_6 results. The calibrations changed slightly with time due to contamination of the detector foils with use (the detector foils were cleaned immediately before the Los Angeles area tests). The maximum changes from the tabulated

SF_6 concentrations in Appendices A-4, A-7, and A-8 are listed below in Table A-2.

TABLE A-2

Maximum Change from Tabulated SF_6 Concentrations

Chromatograph	Moss Landing Studies	Los Angeles Studies
Y1	-13.4%	+28.5%
Y2	- 3.8%	- 9.5%
Z1	- 5.9%	+12.8%
Z2	-26.2%	-15.5%

As can be seen from Table A-2, the tabulated SF_6 values are certainly accurate to ± 30%, with most of the data accurate to ± 15%. To obtain further accuracy, a linear approximation of the calibration change with time can be applied to each data point; it is estimated that the accuracy obtained will be within ± 5%. This procedure was not applied in view of the minimal influence that this correction would have upon the results.

APPENDIX A-3

Calculation of Stack Gas Flow Rates

Stack gas flow rates were calculated for the Moss Landing tests by the California Air Resources Board (Goodley, 1975) and for the Los Angeles tests by the Los Angeles County Air Pollution Control District (Wilson, 1975). However, the ARB values were expressed on a wet basis, while the APCD values were expressed on a dry basis. It was decided to express all flow rates on a wet basis in order to compare results in a consistent manner.

The stack gas flow rates for the Moss Landing tests (Unit 7) calculated by Goodley (1975) are listed in Table A-3. The stack gas flow rates for the Los Angeles tests (Unit 6, both plants) were recalculated on a wet basis using the values for fuel flow rate and excess oxygen listed in Wilson (1975). These stack gas flow rates are also listed in Table A-3; the numbers are approximately 10% higher than the APCD values due to the presence of water vapor. The concentration of SF_6 in the stack given in Table 2 and Table 5 was calculated by dividing the SF_6 flow rate by the stack gas flow rate in Table A-3.

TABLE A-3

Stack Gas Flow Rates (Expressed on a Wet Basis)

Test	Stack Gas Flow Rate SCFM (ft^3/min at 1 atm, 60° F)
Moss Landing Test No. 1	1.41×10^6
Moss Landing Test No. 2	1.30×10^6
Moss Landing Test No. 3	1.23×10^6
Long Beach Test No. 1	7.04×10^5
Long Beach Test No. 2	7.43×10^5
Long Beach Test No. 3	7.58×10^5
Long Beach Test No. 4	1.16×10^6
Long Beach Test No. 5	1.10×10^6
Long Beach Test No. 6	1.16×10^6

APPENDIX A-4

Tabulation of One-Hour Averaged Ground-Level SF_6 Tracer Data

Note: In the following nine tables (Tables A-4 through A-12) the following notation was used:

"n.d." = no data available

"0.0" = SF_6 concentration was less than 10^{-12} parts SF_6 per part of air

TABLE A-4

One-hour Averaged SF_6 Tracer Data (ppt) for Moss Landing Test No. 1 (9/10/74)

Time of Day - Pacific Daylight Savings Time

Location Number	A.M. 8-9	9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	n.d.	4.9	0.0	3.8	4.4	0.0	5.3	14.0	8.9	64.0	2.6	0.0
2	0.0	0.0	0.0	0.0	0.0	1.4	2.5	0.0	0.0	0.0	0.0	0.0
3	0.0	3.3	0.0	0.0	0.0	4.8	7.7	25.0	11.0	1.0	0.0	0.0
4	0.0	0.0	0.0	2.6	0.0	0.0	2.2	0.0	0.0	0.0	1.9	1.8
5	4.0	0.0	0.0	0.0	0.0	0.0	3.2	6.3	7.7	0.0	0.0	0.0
6	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	23.1	0.0
7	0.0	5.9	4.0	0.0	3.3	4.0	3.5	0.0	0.0	1.8	1.2	0.0
8	3.9	0.0	1.9	1.1	0.0	0.0	0.0	3.3	5.7	0.0	0.0	0.0
9	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.0
10	2.2	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	n.d.	0.0
11	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	2.3	0.0	4.3	0.0
12	0.0	0.0	3.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	3.0	0.0	0.0	0.0	0.0	0.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
15	0.0	0.0	0.0	2.4	0.0	0.0	0.0	3.4	3.1	0.0	0.0	0.0
16	0.0	4.4	0.0	3.6	0.0	1.3	0.0	1.6	1.3	14.0	1.1	2.3
17	0.0	3.1	0.0	0.0	5.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0

TABLE A-5

One-hour Averaged SF_6 Tracer Data (ppt) for Moss Landing Test No. 2 (9/11/74)

Time of Day - Pacific Daylight Savings Time

Location Number	A.M. 8-9	9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	0.0	1.7	3.2	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3.4	1.9	1.8	0.0	4.8	1.2	0.0	0.0	1.5	0.0	0.0	0.0
3	0.0	2.1	7.7	2.2	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	5.4	1.1	51.0	3.0	66.0	100.0	420.0	290.0	160.0	10.0	0.0	2.2
5	0.0	2.8	3.2	6.6	0.0	0.0	0.0	1.6	1.4	20.0	0.0	0.0
6	0.0	0.0	3.1	0.0	2.1	3.0	0.0	0.0	0.0	0.0	0.0	0.0
7	4.4	0.0	0.0	4.9	0.0	2.3	0.0	3.0	0.0	0.0	0.0	0.0
8	2.8	0.0	3.6	3.8	7.9	1.8	1.3	1.4	1.4	63.0	2.0	0.0
9	5.9	5.4	16.5	5.2	10.5	363.0	246.0	338.0	187.0	14.2	0.0	n.d.
10	4.1	0.0	0.0	0.0	7.8	5.0	63.0	180.0	290.0	130.0	n.d.	96.0
11	0.0	0.0	0.0	0.0	1.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0
12	4.9	1.0	8.1	3.3	2.1	260.0	230.0	300.0	160.0	41.0	1.7	3.5
15	0.0	0.0	5.5	10.0	12.0	170.0	260.0	n.d.	150.0	110.0	1.2	0.0
17	1.8	8.1	9.3	12.0	6.5	2.5	1.4	0.0	0.0	0.0	0.0	0.0
18	3.6	2.4	5.7	9.1	5.1	42.0	170.0	40.0	76.0	150.0	6.6	1.7

TABLE A-6

One-hour Averaged SF_6 Tracer Data (ppt) for Moss Landing Test No. 3 (9/12/74)

Time of Day - Pacific Daylight Savings Time

Location Number	A.M. 8-9	9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	1.6	2.7	0.0	0.0	3.4	0.0	0.0	1.6	0.0	0.0	0.0	0.0
3	2.9	0.0	0.0	1.3	3.0	0.0	38.0	25.0	43.0	96.0	0.0	1.1
4	4.2	2.1	2.9	0.0	32.0	28.0	2.3	0.0	1.0	0.0	0.0	1.3
5	0.0	0.0	11.0	4.4	92.0	145.0	206.0	257.0	156.0	100.0	1.4	11.0
6	0.0	2.1	0.0	110.0	77.0	19.0	0.0	1.3	0.0	0.0	2.3	0.0
7	2.8	0.0	3.8	86.0	120.0	33.0	0.0	5.2	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	2.7	26.0	172.0	211.0	92.0	107.0	91.0	3.6	1.4
9	0.0	2.4	0.0	0.0	20.0	72.0	7.0	1.8	0.0	1.1	0.0	n.d.
10	1.8	0.0	1.5	2.5	1.7	n.d.	69.0	8.4	28.0	0.0	n.d.	0.0
11	0.0	0.0	0.0	48.0	110.0	82.0	1.7	0.0	0.0	0.0	0.0	0.0
12	4.1	7.5	2.8	2.1	12.0	57.0	42.0	0.0	0.0	0.0	0.0	6.9
13	4.9	6.7	1.5	59.0	77.0	85.0	32.0	107.0	71.0	0.0	n.d.	n.d.
14	0.0	2.6	48.0	88.0	13.0	0.0	2.3	0.0	0.0	0.0	n.d.	n.d.
15	0.0	0.0	0.0	0.0	17.0	43.0	25.0	3.8	0.0	0.0	0.0	1.4
16	0.0	0.0	5.4	1.3	0.0	46.0	69.0	100.0	n.d.	n.d.	90.0	0.0
18	2.8	2.6	2.3	2.6	2.3	26.0	62.0	16.0	3.6	6.8	4.2	1.1

TABLE A-7

One-hour Averaged SF_6 Tracer Data (ppt) for Long Beach Test No. 1 (10/1/74)

Time of Day - Pacific Standard Time

Location Number	A.M. 8-9	9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	10.1	1.7	2.5	0.0	0.0	0.0	7.1	0.0	0.0	8.7	0.0	7.7
4	0.0	0.0	0.0	41.5	40.0	25.6	9.4	47.3	245.0	38.3	0.0	0.0
5	0.0	3.1	1.5	5.4	11.0	0.0	4.3	0.0	0.0	0.0	n.d.	0.0
6	1.6	n.d.	1.2	0.0	4.5	6.4	3.9	4.8	3.8	0.0	0.0	0.0
8	0.0	0.0	0.0	1.3	22.2	14.1	10.9	9.8	17.8	4.2	0.0	0.0
9	0.0	0.0	0.0	1.2	1.4	5.9	6.0	0.0	1.7	0.0	0.0	0.0
10	0.0	0.0	4.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	1.1	0.0	0.0	0.0	0.0	2.0	1.6	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
17	9.4	13.3	22.1	21.1	12.8	9.6	24.8	32.4	47.8	22.9	30.9	5.1
19	0.0	0.0	0.0	0.0	1.0	0.0	0.0	4.1	1.8	5.6	5.1	2.7
20	2.8	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	2.3	1.4	1.9	2.5	0.0	0.0	9.7	1.3	9.3	5.2	4.8	10.7
22	2.4	1.4	3.5	4.7	6.5	4.3	8.7	21.9	16.7	11.1	14.4	0.0

TABLE A-8

One-hour Averaged SF_6 Tracer Data (ppt) for Long Beach Test No. 2 (10/11/74)

Time of Day - Pacific Standard Time

Location Number	A.M. 8-9	9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	0.0	0.0	1.9	4.5	1.8	3.2	2.6	0.0	1.7	8.1	4.4	1.9
2	2.7	1.3	8.1	6.4	0.0	0.0	41.2	27.7	18.6	4.7	1.9	0.0
3	2.0	0.0	2.9	0.0	0.0	2.6	8.1	3.2	4.6	3.5	0.0	4.8
4	3.1	6.6	6.7	4.8	3.0	5.7	32.3	51.7	40.9	6.0	0.0	7.1
5	4.8	6.7	7.9	7.4	12.7	13.0	6.5	0.0	5.7	4.4	n.d.	5.4
6	3.5	7.2	8.1	3.7	7.5	2.7	3.2	3.3	2.3	7.5	6.2	3.0
7	6.1	2.8	4.6	8.5	6.7	7.5	6.3	6.2	6.0	4.4	3.6	0.0
8	2.0	0.0	0.0	0.0	0.0	2.3	9.6	82.6	18.7	3.8	0.0	0.0
9	0.0	0.0	0.0	1.5	7.5	1.5	2.0	3.8	0.0	0.0	1.8	2.1
10	7.9	5.3	8.8	8.1	1.5	6.6	9.2	3.9	2.1	1.1	4.2	5.2
11	7.3	4.9	3.9	5.6	4.7	3.0	2.5	5.3	0.0	4.0	3.9	0.0
14	0.0	5.6	1.6	13.9	2.8	0.0	3.6	n.d.	4.2	5.0	3.3	3.0
16	2.9	3.9	2.3	3.0	2.1	4.2	6.4	3.7	4.7	3.2	2.5	2.6
17	15.1	18.8	32.4	40.0	11.0	17.0	88.0	10.0	16.8	61.1	38.6	39.7
18	3.3	9.9	18.0	17.4	22.1	16.5	16.3	19.9	52.6	52.9	24.7	20.8
19	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*	n.d.*
20	7.0	0.0	3.0	7.7	2.4	3.0	6.5	0.0	0.0	0.0	0.0	3.0
21	6.2	6.1	7.7	2.6	4.6	6.4	8.7	5.6	3.1	6.7	5.8	10.7
22	7.7	4.6	3.5	3.5	4.8	11.5	4.0	10.9	75.0	10.3	9.7	11.4

*see Appendix A-9

TABLE A-9

One-hour Averaged SF_6 Tracer Data (ppt) for Long Beach Test No. 3 (10/17/74)

Time of Day - Pacific Standard Time

Location Number	A.M. 8-9	9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	n.d.	8.6	5.1	3.3	4.5	0.0	0.0	2.5	3.8	4.9	4.8	2.2
2	4.1	5.4	1.8	10.5	9.2	4.0	0.0	85.5	9.5	0.0	3.3	1.4
3	7.8	6.8	2.7	0.0	2.8	0.0	0.0	0.0	2.3	4.1	2.2	0.0
4	5.4	7.0	0.0	24.7	121.0	7.9	0.0	69.7	16.7	3.7	0.0	2.9
5	2.7	1.8	3.6	5.2	1.7	5.1	26.6	14.8	10.5	68.4	1.7	3.5
6	11.5	10.7	14.7	10.8	6.8	4.7	5.1	5.3	22.1	6.5	4.0	0.0
7	3.5	3.7	2.2	3.3	3.5	0.0	0.0	2.9	9.9	0.0	3.0	2.6
8	5.5	6.7	2.3	2.3	1.8	71.4	28.8	3.4	16.4	107.0	4.5	1.4
9	2.6	2.1	0.0	1.9	1.1	25.0	0.0	0.0	0.0	3.9	0.0	0.0
10	21.6	15.3	14.9	8.3	10.5	6.3	9.9	2.6	1.2	0.0	0.0	0.0
11	5.5	4.4	3.5	4.9	7.5	8.6	7.9	4.7	6.0	7.6	6.1	4.1
16	0.0	4.5	0.0	0.0	4.1	4.9	5.3	5.4	5.5	2.8	2.2	4.5
17	6.8	0.0	4.9	1.7	33.9	33.6	16.8	59.0	57.6	61.0	84.8	41.5
18	6.9	3.8	5.6	6.4	0.0	23.2	28.7	13.0	0.0	8.6	48.0	34.9
19	11.6	8.2	6.2	1.5	1.6	1.9	5.3	3.6	0.0	0.0	5.6	0.0
21	5.7	4.4	4.4	0.0	0.0	6.3	19.0	6.8	4.6	17.5	10.3	12.8
22	0.0	0.0	0.0	4.4	10.1	12.0	5.2	6.3	11.7	5.1	n.d.	n.d.

TABLE A-10

One-hour Averaged SF_6 Tracer Data (ppt) for Long Beach Test No. 4 (10/25/74)

Time of Day - Pacific Standard Time

Location Number	A.M. 8-9	9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	n.d.	1.8	1.4	0.0	0.0	1.1	1.4	0.0	0.0	1.5	0.0	0.0
2	3.7	2.0	2.7	47.0	69.0	48.0	93.0	29.0	127.0	2.0	0.0	4.0
3	2.0	0.0	0.0	1.0	13.0	0.0	0.0	0.0	2.5	1.4	1.0	0.0
4	3.6	19.1	0.0	17.0	51.1	24.0	81.1	113.0	164.0	3.2	3.3	0.0
5	3.0	4.4	4.6	0.0	1.8	0.0	0.0	1.5	3.2	0.0	0.0	1.2
6	n.d.	5.2	2.5	2.8	1.8	1.2	0.0	0.0	1.6	1.7	2.3	0.0
7	2.8	3.5	3.8	0.0	24.5	5.0	0.0	0.0	0.0	14.1	1.9	0.0
8	4.7	2.5	3.0	2.2	46.8	46.3	13.8	21.9	53.2	40.4	0.0	0.0
9	0.0	0.0	3.5	7.7	5.4	28.0	4.6	0.0	0.0	0.0	4.4	1.6
10	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.2
11	2.5	0.0	1.9	2.2	0.0	0.0	0.0	1.2	0.0	0.0	1.6	3.4
16	1.4	3.6	0.0	0.0	6.1	5.2	1.4	0.0	0.0	1.1	0.0	0.0
17	28.4	0.0	24.0	18.0	11.7	10.7	8.3	44.9	12.7	36.9	6.2	0.0
19	7.5	2.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	6.5
21	4.8	0.0	3.9	0.0	1.9	0.0	13.0	6.0	6.3	0.0	0.0	5.7
22	2.3	1.0	6.9	5.3	3.5	0.0	1.7	0.0	0.0	0.0	0.0	0.0

TABLE A-11

One-hour Averaged SF_6 Tracer Data (ppt) for Long Beach Test No. 5 (10/30/74)

Time of Day - Pacific Standard Time

Location Number	A.M. 9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
1	n.d.	0.0	0.0	4.1	0.0	0.0	3.1	0.0	0.0	2.5	0.0	0.0
2	1.5	0.0	0.0	0.0	0.0	28.7	172.0	314.0	28.2	0.0	1.8	1.4
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.5	3.8	5.2	0.0	7.0	109.0	5.1	31.3	113.0	5.1	4.6	7.8
5	1.7	0.0	0.0	1.8	19.8	1.7	1.7	0.0	0.0	1.7	2.8	7.9
6	2.6	0.0	1.9	0.0	0.0	0.0	0.0	0.0	2.8	2.3	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	9.3	0.0
8	0.0	2.3	0.0	0.0	0.0	4.9	67.3	38.4	5.7	3.0	4.4	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n.d.	n.d.	n.d.
10	3.0	6.1	7.1	2.4	1.9	5.7	3.2	4.9	0.0	2.0	2.9	5.3
11	0.0	3.4	1.8	2.5	5.7	2.0	0.0	0.0	1.0	0.0	0.0	2.6
12	3.9	5.3	0.0	0.0	0.0	20.2	1.8	0.0	0.0	1.2	2.2	0.0
13	4.7	0.0	0.0	0.0	0.0	10.3	14.8	2.5	12.7	37.4	26.5	22.9
15	0.0	0.0	3.3	0.0	0.0	6.5	8.6	0.0	0.0	1.8	0.0	2.4
16	0.0	3.5	0.0	0.0	0.0	9.4	2.4	0.0	0.0	0.0	0.0	0.0
17	0.0	3.2	0.0	0.0	15.7	8.9	15.1	1.6	9.7	86.1	53.1	57.9
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	2.1	0.0	0.0	0.0	0.0	6.5	0.0	1.1	0.0	2.1
22	0.0	0.0	0.0	3.6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

TABLE A-12

One-hour Averaged SF_6 Tracer Data (ppt) for Long Beach Test No. 6 (11/7/74)

Time of Day - Pacific Standard Time

Location Number	A.M. 9-10	10-11	11-12	P.M. 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
2	2.2	5.1	n.d.*	5.0	73.1	85.1	110.0	18.1	11.3	46.7	4.3	4.9
3	0.0	9.8	17.6	0.0	n.d.*	0.0	0.0	2.9	2.8	4.2	2.5	3.0
4	0.0	0.0	8.7	8.0	15.2	132.0	69.3	31.8	5.9	21.1	4.1	n.d.
5	21.1	38.5	25.3	7.0	4.2	9.2	19.7	16.8	37.5	14.3	5.9	10.9
6	19.9	0.0	0.0	162.0	23.4	3.8	46.9	23.9	117.0	73.3	15.7	8.2
7	2.5	0.0	64.3	41.9	28.1	139.0	3.2	2.3	3.1	15.2	28.5	13.8
9	0.0	29.7	5.1	0.0	3.0	71.9	1.7	1.5	0.0	0.0	27.8	2.6
10	2.6	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	4.7	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2
12	0.0	7.7	0.0	0.0	0.0	2.6	0.0	39.4	0.0	2.3	0.0	0.0
13	1.5	0.0	0.0	0.0	1.9	21.2	63.8	54.6	4.6	11.1	27.0	11.2
15	4.2	9.3	7.6	18.1	53.5	117.0	10.5	3.2	1.9	0.0	4.2	0.0
16	8.8	6.2	3.2	0.0	0.0	3.9	63.5	3.4	n.d.	n.d.	n.d.	n.d.
17	18.7	80.0	2.6	12.2	14.3	28.5	8.8	36.8	11.3	7.1	95.7	56.0
19	2.2	21.0	9.2	0.0	2.0	0.0	9.2	15.1	16.1	4.9	2.3	4.2
21	4.4	7.9	0.0	2.3	0.0	0.0	21.4	14.8	4.1	8.4	10.4	6.1
22	3.0	0.0	13.0	13.9	0.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

* see Appendix A-9

APPENDIX A-5

Gaussian Plume Model Calculation

For Moss Landing Test No. 2 (9/11/74), the inversion height in the afternoon was roughly 244 m (800 ft), as determined by MRI airborne data (see Table 3). The effective stack height was not measured in the afternoon, however for calculations close to the source, it will be assumed identical to the inversion height, 244 m.

For distances closer than 7.5 km to the source, the following equation was used (Turner, 1970):

$$c = \frac{Q}{\pi \sigma_y \sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 - \frac{1}{2}\left(\frac{L}{\sigma_z}\right)^2 \right] \tag{A-2}$$

Equation (A-2) was used in an inverted sense, i.e., ground-level concentrations at position x from the source associated with an elevated source located at z = L would be identical to concentrations at position x and z = L associated with a ground-level source. For distances further than 15 km from the source, the well-mixed dispersion equation was used (Turner, 1970):

$$c = \frac{Q}{\sqrt{2\pi}\ \sigma_y L u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 \right] \tag{A-3}$$

It should be noted that all the sampling locations were at distances greater than 15 km, when equation (A-3) is applicable.

Stability class D, the neutral stability case, was used to estimate values of σ_y and σ_z in order to most closely represent the traverse data result in Table 8. Stability class D also resulted in higher ground-level concentrations than any other stability class; for more stable stability classes, the calculated plume does not touch down at the sampler locations.

The values used in equations (A-2) and (A-3) were as follows:

$Q = 9.76$ g/sec

$L = 244$ m

$u = 10$ m/sec

The concentration values calculated represented 10-minute averaged samples. In order to adjust the concentration values to represent 3-hour averages, the following formula was used, as suggested by Turner (1970):

$$\frac{c\ (180\ \text{min})}{c\ (10\ \text{min})} = \left(\frac{180\ \text{min}}{10\ \text{min}}\right)^{-1/5} = 0.561$$

It should be noted that Hino (1968) recommended a $t^{-1/2}$ correction, which would reduce the concentrations even further. The resulting Gaussian plume concentration isopleths are plotted in Figure 57, which should be compared to the experimental isopleths in Figure 18.

APPENDIX A-6

NO_2 Formation Calculations

Case 1. Exponential Dispersion in the Absence of Ozone

The kinetics of the reaction,

$$2NO + O_2 \rightarrow 2NO_2 \qquad \text{(A-4)}$$

are fairly well-known. The rate expression for the decomposition of NO is thought to be second order in NO and first order in O_2,

$$\left[\frac{d(NO)}{dt}\right]_{reaction} = -\,k(NO)^2(O_2) \qquad \text{(A-5)}$$

with the rate constant $k = 1.47 \times 10^{-9}$ ppm^{-2} min^{-1} applicable at 25^oC (England and Corcoran, 1975).

The effects of atmospheric dispersion can be modeled most simply by assuming an exponential dilution of the available NO for reaction. In the absence of any oxidation reaction,

$$(NO) = (NO)_o\ e^{-t/t_o} \qquad \text{(A-6)}$$

where t_o is a characteristic time for atmospheric dispersion. Thus,

$$\left[\frac{d(NO)}{dt}\right]_{dispersion} = -\,\frac{(NO)}{t_o} \qquad \text{(A-7)}$$

The loss rate of NO associated with only the O_2 oxidation reaction is given by equation (A-5). Therefore, the total loss rate of NO is given by:

$$\frac{d(NO)}{dt} = -\,k(NO)^2(O_2) - \frac{(NO)}{t_o} \qquad \text{(A-8)}$$

Since the concentration of oxygen remains constant, equation (A-8) may be integrated to yield the following result,

$$(NO) = \frac{(NO)_o \, e^{-t/t_o}}{1 + k_1(1 - e^{-t/t_o})} \tag{A-9}$$

where k_1 is a constant defined by:

$$k_1 = k(NO)_o(O_2)t_o \tag{A-10}$$

The expression for the rate of change of NO_2 with respect to time is quite similar to equation (A-8), since:

$$\left[\frac{d(NO_2)}{dt}\right]_{reaction} = +k(NO)^2(O_2) \tag{A-11}$$

Assuming that the NO_2 disperses at the same rate as NO yields:

$$\left[\frac{d(NO_2)}{dt}\right]_{dispersion} = -\frac{(NO_2)}{t_o} \tag{A-12}$$

Thus, the total rate of change of NO_2 with respect to time is given by:

$$\frac{d(NO_2)}{dt} = k(NO)^2(O_2) - \frac{(NO_2)}{t_o} \tag{A-13}$$

Substituting equation (A-9) into equation (A-13) yields:

$$\frac{d(NO_2)}{dt} = \frac{k(O_2)(NO)_o^2 \, e^{-2t/t_o}}{\left[1 + k_1(1 - e^{-t/t_o})\right]^2} - \frac{(NO_2)}{t_o} \tag{A-14}$$

Assuming that the oxygen concentration remains constant, the solution of equation (A-14) yields the following result,

$$(NO_2) = \frac{k_1(NO)_o \, e^{-t/t_o} \, (1 - e^{-t/t_o})}{1 + k_1(1 - e^{-t/t_o})} \tag{A-15}$$

with the constant k_1 as defined by equation (A-10). It should be noted that equation (A-15) predicts that the concentration of NO_2 will initially increase due to the oxidation of NO and will later decrease due to dispersion. Using equations (A-9) and (A-15), the fraction of NO_2 as a function of time is given by the following expression,

$$\frac{(NO_2)}{(NO) + (NO_2)} = \frac{k_1(1 - e^{-t/t_0})}{1 + k_1(1 - e^{-t/t_0})} \tag{A-16}$$

with k_1 as defined in equation (A-10). A characteristic time t_0 of approximately 10 min will correctly predict the observed dilution associated with the tracer data. Using the values $(NO)_0$ = 200 ppm, t_0 = 10 min, (O_2) = 21%, and t = 60 min, the amount of NO oxidized to NO_2 predicted by equation (A-16) is 38.0%. It should be noted that, according to equation (A-16), the assumed dilution effectively quenches the NO reaction after about 30 min. In the limit of infinite time, equation (A-16) becomes:

$$\frac{(NO_2)}{(NO) + (NO_2)} = \frac{k_1}{1 + k_1} \tag{A-17}$$

Using the same parameter values as above, the maximum amount of NO_2 which can form, given by equation (A-17), is 38.1% - essentially the same value as at 60 min.

Case 2. Exponential Dispersion with Ozone Present

The oxidation of NO by O_3, given by the following expression,

$$NO + O_3 \rightarrow NO_2 + O_2 \tag{A-18}$$

is considered to be quite rapid. The rate expression is both first order in NO and in O_3,

$$\left[\frac{d(NO)}{dt}\right]_{reaction} = -k\,(NO)(O_3) \tag{A-19}$$

with the rate constant k = 28.8 ppm^{-1} min^{-1} applicable at 25°C (Johnston and Crosby, 1954). Again, the assumption of an exponential dilution, with a characteristic dispersion time t_0, leads to the following expression for the rate of loss of NO:

$$\frac{d(NO)}{dt} = -k(O_3)(NO) - \frac{(NO)}{t_o} \tag{A-20}$$

If the concentration of ozone remains relatively constant, equation (A-20) can be integrated to yield:

$$(NO) = (NO)_o\, e^{-[k(O_3) + 1/t_o]t} \tag{A-21}$$

The expression for the rate of change of NO_2 with respect to time is quite similar to equation (A-21). The expression, including the effects of an exponential dispersion, is given by:

$$\frac{d(NO_2)}{dt} = k(NO)(O_3) - \frac{(NO_2)}{t_o} \tag{A-22}$$

Substituting equation (A-21) for the concentration of NO yields:

$$\frac{d(NO_2)}{dt} = k(O_3)(NO)_o\, e^{-[k(O_3) + 1/t_o]t} - \frac{(NO_2)}{t_o} \tag{A-23}$$

Solution of equation (A-23) yields the following result:

$$(NO_2) = (NO)_o\, e^{-t/t_o}\,(1 - e^{-k(O_3)t}) \tag{A-24}$$

From equations (A-21) and (A-24), the expression for the fraction of NO_2 produced from the oxidation by O_3 as a fraction of time is given by:

$$\frac{(NO_2)}{(NO) + (NO_2)} = 1 - e^{-k(O_3)t} \tag{A-25}$$

If the concentration of ozone remains constant at 0.01 ppm and t = 60 min, the amount of NO_2 formed from equation (A-25) is 100%. Even if the concentration of ozone is extremely low, 0.001 ppm, the amount of NO_2 formed in 60 min is 82.2%. Thus, if any reasonable amount of ozone is present, the conversion of NO to NO_2 proceeds quite rapidly.

APPENDIX A-7

Tabulation of Airborne SF_6 Tracer Data

Note: In the data tabulation, the following notation was used:

"n.d." = no data available

"0.0" = SF_6 concentration was less than 1 ppt

The traverse positions refer to locations and times described more fully in the Meteorology Research, Inc. report.

Moss Landing Test No. 1 (9/10/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
A to A	800	14.1
A to A	1000	171.0
A to A	1200	209.0
A to A	1400	889.0
A to A	1600	19.1
A to A	1800	9.8
A to A	1500	1840.0
A to A	1300	2450.0
A to A	1100	25.2
B to C	1000	60.9
B to C	800	35.9
B to C	1200	4340.0
B to C	1400	141.0
B to C	1300	1640.0
B to C	1100	984.0
B to C	900	46.2
D to E	1400	606.0
E to D	1600	109.0
D to E	1200	2120.0
E to D	1200	1370.0
D to E	1300	1130.0
E to D	1100	1500.0
D to E	900	1100.0
F to G	1000	653.0
G to F	1100	434.0
F to G	1200	466.0
G to F	1300	58.0
F to G	1400	150.0
G to F	1500	61.6
F to G	1600	32.5

Moss Landing Test No. 2 (9/11/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
A to B	1000	9.7
A to B	1200	28.9
A to B	1400	136.0
A to B	1300	70.2
A to B	1500	2280.0
A to B	1500	96.7
A to B	1600	3.8

Moss Landing Test No. 3 (9/12/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
A to B	500	16.8
B to A	700	18.6
A to B	900	36.5
B to A	1100	7.1
A to B	1300	6.1
B to A	1500	23.0
A to B	1700	33.7
B to A	1900	36.7
C to D	700	8.3
D to C	600	20.4
C to D	500	19.1
E to F	700	17.5
E to F	600	29.0
E to F	800	66.0
E to F	900	207.0
E to F	1000	162.0
E to F	1200	217.0
E to F	1300	73.8
E to F	1400	0.0
E to F	1500	3.0

Long Beach Test No. 1 (10/1/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
A to B	1000	223.0
A to B	1000	150.0
A to B	1100	36.4
A to B	1200	1.2
C to D	1000	6.1
D to C	1000	14.7
E to F	1000	130.0
F to E	1100	46.9
E to F	1200	45.4
F to E	1300	2.4
E to F	1400	2.2
F to E	1500	0.0
Spiral, Los Alamitos	-	41.6
G to H	1500	9.2
H to G	1400	6.5
G to H	1300	5.0
H to G	1200	2.9
G to H	1100	3.0
Spiral, Fullerton	-	n.d.
Spiral, G	-	0.0

Long Beach Test No. 2 (10/11/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt	Traverse Location	Altitude (ft)	$[SF_6]$, ppt
A to B	1000	154.0	Spiral, K	--	3.4
A to B	1100	n.d.	Spiral, Fullerton	--	36.3
A to B	1200	143.0	Spiral, Los Alamitos	--	3.9
A to B	1300	171.0	Spiral, Riverside	--	4.1
A to B	1400	262.0			
A to B	1500	85.9			
A to B	1600	142.0			
A to B	1700	168.0			
Spiral, Los Alamitos	--	6.4			
C to D	1000	76.9			
D to C	1250	113.0			
C to D	1450	69.5			
D to C	1600	80.7			
C to D	1800	103.0			
G to F	1800	36.5			
F to G	2000	42.5			
G to F	2200	30.2			
F to G	1600	46.7			
G to F	1400	54.5			
F to G	1200	83.5			
G to F	1000	55.5			
H to J	1500	6.2			
J to H	1300	n.d.			
H to J	1100	18.9			
J to H	1700	7.8			
H to J	1900	34.5			
J to H	2100	32.8			
K to L	2200	4.8			
L to K	2000	4.9			
K to L	1800	4.5			
L to K	1500	5.7			
K to L	1300	8.3			

Long Beach Test No. 3 (10/17/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
A to B	1100	4.4
A to B	1200	0.0
A to B	1000	311.0
C to D	1000	22.6
D to C	1100	5.1
Spiral, Los Alamitos	--	40.4
E to F	1000	6.2
F to E	1100	1.4
E to F	1200	4.3
F to E	1400	5.4
G to H	1400	20.9
H to G	1300	21.7
Spiral, Fullerton	--	24.9
G to H	1600	4.8
Spiral, Shephard	--	4.7
Spiral, El Monte	--	4.3
J to K	1500	19.5
Spiral, Chino	--	3.5
Spiral, Los Alamitos	--	4.5

Long Beach Test No. 4 (10/25/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt	Traverse Location	Altitude (ft)	$[SF_6]$, ppt
Spiral, Los Alamitos	--	65.2	H to G	2000	1.6
A to B	1000	201.0	G to H	2200	10.5
A to B	1100	382.0	Spiral, Fullerton	--	71.9
A to B	1200	120.0	Spiral, S.A. Canyon	--	0.0
A to B	1300	310.0	I to J	1400	0.0
A to B	1400	10.1	J to I	1600	0.0
A to B	1500	103.0	I to J	1800	1.1
A to B	1600	0.0	J to I	2000	54.5
A to B	1700	0.0	I to J	2200	21.2
A to B	1400	115.0			
A to B	1000	464.0			
C to D	1000	258.0			
D to C	1100	59.8			
C to D	1200	78.8			
D to C	1300	n.d.*			
C to D	1400	0.0			
D to C	1250	29.1			
E to F	1000	21.2			
F to E	1100	5.4			
E to F	1200	3.6			
G to H	1000	n.d.			
H to G	1100	n.d.			
H to G	1200	1.9			
G to H	1300	4.2			
H to G	1400	0.0			
G to H	1500	0.0			
H to G	1600	35.5			
G to H	1700	42.2			
H to G	1800	15.3			
G to H	1900	22.8			

* See Appendix A-9.

Long Beach Test No. 5 (10/30/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
Spiral, Los Alamitos	--	0.0
A to B	1000	364.0
A to B	1100	279.0
A to B	1200	139.0
A to B	1300	123.0
A to B	1400	232.0
A to B	1500	52.6
A to B	1600	7.0
A to B	1700	0.0
C to D	1000	69.7
D to C	1100	94.3
E to F	1200	129.0
F to E	1300	44.7
E to F	1400	38.4
F to E	1500	49.6
E to F	1600	26.6
F to E	1700	6.8
E to F	1800	0.0
F to E	1100	47.9
E to F	1000	n.d.*
G to H	1000	53.7
H to G	1100	29.3
G to H	1200	35.8
H to G	1300	61.1
G to H	1400	30.7
H to G	1500	34.6
G to H	1600	49.2
H to G	1700	14.6
G to H	1800	12.3
H to G_2	1900	14.2
G_2 to H	2000	n.d.

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
Spiral, Fullerton	--	n.d.
Spiral, S.A. Canyon	--	n.d.
J to K	1400	n.d.
K to J	1600	0.0
J to K	1800	4.0
K to J	2000	3.9
J to K	2200	3.2

* See Appendix A-9

Long Beach Test No. 6 (11/7/74)

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
A to B	1000	102.0
A to B	1100	44.3
C to B	1200	217.0
C to B	1300	210.0
C to B	1400	434.0
C to B	1500	378.0
C to B	1600	214.0
C to B	1700	183.0
C to B	1800	24.7
C to B	1900	13.1
Spiral, Los Alamitos	--	19.8
Spiral, Los Alamitos	--	253.0
D to E	1000	153.0
E to D	1100	190.0
D to E	1200	212.0
E to D	1300	66.0
D to E	1400	51.3
D to E	1600	n.d.*
E to D	1700	15.5
D to E	1800	21.2
F to G_1	1000	92.9
G_2 to F	1100	60.6
F to G_1	1200	46.5
G_2 to F	1300	25.3
G_2 to F	1500	14.7
F to G_1	1600	14.5
G_2 to F	1700	33.0
F to G_1	1800	20.8
G_2 to F	1900	22.1
F to G_1	2000	268.0

Traverse Location	Altitude (ft)	$[SF_6]$, ppt
Spiral, Fullerton	--	1.1
H to J	1000	3.2
J to H	1100	6.4
H to J	1200	8.2
J to H	1300	5.6
H to J	1400	15.4
J to H	1500	12.0
H to J	1600	18.2
J to H	1800	29.7
H to J	2000	22.4

*See Appendix A-9.

APPENDIX A-8

Tabulation of Ground-Level Traverse SF_6 Tracer Data

Note: In the data tabulation, the following notation was used:

"n.d." = no data available

"0.0" = SF_6 concentration was less than 1 ppt

Moss Landing Test No. 2 (9/11/74)
Traverse No. 1
Traverse on Main St., Salinas, traveling North
Starting point: intersection of S. Main St. and E. Blanco Rd.
Time: 2:45-3:00 p.m. (PDT)

Crosswind Distance, km	[SF_6], ppt
0.0	0.0
0.2	n.d.
0.4	5.5
0.6	2.4
0.9	4.0
1.1	5.0
1.3	7.3
1.4	20.0
1.6	21.0
1.8	100.0
2.0	70.0
2.3	130.0
2.4	180.0
2.7	300.0
2.9	340.0
3.1	440.0
3.3	400.0
3.4	330.0
3.5	470.0
3.7	600.0

Moss Landing Test No. 2 (9/11/74)
Traverse No. 2
Traverse from E. Blanco Rd. to Natividad Rd. traveling North
Starting point: intersection of S. Main St. and E. Blanco Rd.
Time: 3:00-3:20 p.m. (PDT)

Crosswind Distance, km	$[SF_6]$, ppt
1.2	31.0
1.6	340.0
2.0	55.0
2.2	170.0
2.5	210.0
2.9	430.0
3.2	430.0
3.4	400.0
3.5	370.0
3.8	640.0
3.9	470.0
4.1	290.0
4.1	320.0
4.2	460.0
4.2	530.0
4.5	350.0
4.5	250.0
4.5	330.0
4.6	510.0
4.6	380.0
4.6	150.0
4.7	290.0
4.7	250.0
5.1	130.0
5.4	15.0
5.7	n.d.

Long Beach Test No. 2 (10/11/74)
Traverse No. 1
Traverse on Highway 5 traveling North
Starting point: intersection of 5 and 22
Time: 3:23-3:45 p.m. (PST)

Miles from 5-22	[SF_6], ppt
0.0	3.0
0.5	4.6
1.0	1.9
1.5	3.1
2.0	4.3
2.5	5.7
3.0	1.8
3.5	3.0
4.0	10.0
4.5	18.0
5.0	43.0
5.5	62.7
6.0	49.2
6.5	27.9
7.0	19.2
7.5	24.0
8.0	58.6
8.5	134.0
9.0	257.0
9.5	73.4
10.0	22.0
11.0	8.2
12.0	3.3
13.0	7.2
14.0	3.0
15.0	4.0
16.0	4.0
17.0	3.7
18.0	5.2
19.0	5.2

Long Beach Test No. 3 (10/17/74)
Traverse No. 1
Traverse on Highway 5 traveling South
Starting point: intersection of 5 and 605
Time: 3:14-3:35 p.m. (PST)

Miles from 5-605	$[SF_6]$, ppt	Miles from 5-605	$[SF_6]$, ppt
0.0	2.9	14.0	0.0
0.5	0.0	14.5	1.5
1.0	0.0	15.0	0.0
1.5	4.5	15.5	0.0
2.0	0.0	16.0	0.0
2.5	0.0	16.5	0.0
3.0	2.6	17.0	2.4
3.5	0.0	17.5	0.0
4.0	6.2	18.0	0.0
4.5	20.6	18.5	3.8
5.0	16.5	19.0	0.0
5.5	48.2	19.5	1.8
6.0	39.8		
6.5	38.3		
7.0	44.6		
7.5	32.2		
8.0	51.7		
8.5	197.0		
9.0	160.0		
9.5	215.0		
10.0	147.0		
10.5	54.5		
11.0	12.3		
11.5	4.1		
12.0	0.0		
12.5	0.0		
13.0	2.0		
13.5	0.0		

Long Beach Test No. 4 (10/25/74)
Traverse No. 1
Traverse on Highway 5 traveling North
Starting point: intersection of 5 and 22
Time: 2:08-2:27 p.m. (PST)

Miles from 5-22	[SF_6], ppt	Miles from 5-22	[SF_6], ppt
0.0	0.0	14.0	0.0
0.5	2.0	14.5	0.0
1.0	0.0	15.0	0.0
1.5	0.0	15.5	0.0
2.0	0.0	16.0	1.9
2.5	0.0	16.5	0.0
3.0	0.0	17.0	0.0
3.5	0.0		
4.0	2.9		
4.5	1.0		
5.0	2.2		
5.5	0.0		
6.0	2.5		
6.5	0.0		
7.0	0.0		
7.5	0.0		
8.0	60.9		
8.5	222.0		
9.0	309.0		
9.5	103.0		
10.0	18.6		
10.5	6.8		
11.0	0.0		
11.5	1.7		
12.0	0.0		
12.5	3.5		
13.0	2.8		
13.5	0.0		

Long Beach Test No. 4 (10/25/74)
Traverse No. 2
Traverse on Highways 60-71 traveling East
Starting point: intersection of 60 and 605
Time: 2:36-3:12 p.m. (PST)

Miles from 60-605	$[SF_6]$, ppt	Miles from 60-605	$[SF_6]$, ppt
0.0	0.0	15.0	29.0
0.5	0.0	15.5	25.6
1.0	0.0	16.0	24.0
1.5	2.9	16.5	37.5
2.0	0.0	17.0	54.9
2.5	0.0	17.5	42.7
3.0	1.1	18.0	61.0
3.5	0.0	18.5	32.9
4.0	0.0	19.0	40.5
4.5	2.8	19.5	28.3
5.0	0.0	20.0	13.8
5.5	0.0	20.5	15.5
6.0	2.7	21.0	5.5
6.5	84.0	21.5	8.5
7.0	106.0	22.0	7.2
7.5	91.0	22.5	3.9
8.0	95.0	23.0	1.7
8.5	143.0	23.5	0.0
9.0	52.5	24.0	1.1
9.5	35.0	24.5	0.0
10.0	85.9	25.0	0.0
10.5	53.4	25.5	0.0
11.0	36.5	26.0	0.0
11.5	59.8	26.5	0.0
12.0	43.3	27.0	1.2
12.5	57.0	27.5	0.0
13.0	40.3	28.0	0.0
13.5	60.3	28.5	0.0
14.0	45.9	29.0	0.0
14.5	30.5	29.5	2.2

Long Beach Test No. 5 (10/30/74)
Traverse No. 1
Traverse on Highway 5 traveling South
Starting point: intersection of 5 and 605
Time: 2:39-2:58 p.m. (PST)

Miles from 5-605	[SF_6], ppt	Miles from 5-605	[SF_6], ppt
0.0	0.0	14.0	0.0
0.5	0.0	14.5	0.0
1.0	0.0	15.0	1.4
1.5	0.0	15.5	0.0
2.0	2.2	16.0	0.0
2.5	0.0	16.5	0.0
3.0	0.0	17.0	0.0
3.5	0.0		
4.0	0.0		
4.5	0.0		
5.0	0.0		
5.5	1.7		
6.0	0.0		
6.5	4.9		
7.0	100.0		
7.5	163.0		
8.0	174.0		
8.5	25.5		
9.0	18.7		
9.5	4.8		
10.0	1.7		
10.5	1.6		
11.0	0.0		
11.5	0.0		
12.0	0.0		
12.5	1.3		
13.0	0.0		
13.5	0.0		

Long Beach Test No. 5 (10/30/74)

Traverse No. 2

Traverse on Highways 60-71 traveling East

Starting point: intersection of 60 and 605

Time: 3:07-3:41 p.m. (PST)

Miles from 60-605	[SF_6], ppt	Miles from 60-605	[SF_6], ppt
0.0	0.0	15.0	11.5
0.5	0.0	15.5	11.4
1.0	3.3	16.0	11.6
1.5	1.9	16.5	23.8
2.0	0.0	17.0	14.6
2.5	0.0	17.5	28.4
3.0	2.1	18.0	47.6
3.5	0.0	18.5	65.6
4.0	1.2	19.0	35.7
4.5	0.0	19.5	54.7
5.0	0.0	20.0	42.4
5.5	0.0	20.5	5.1
6.0	1.5	21.0	38.0
6.5	0.0	21.5	23.0
7.0	2.6	22.0	25.3
7.5	0.0	22.5	0.0
8.0	1.5	23.0	0.0
8.5	3.0	23.5	0.0
9.0	3.5	24.0	0.0
9.5	3.4	24.5	0.0
10.0	4.6	25.0	0.0
10.5	5.3	25.5	0.0
11.0	5.3	26.0	0.0
11.5	8.2	26.5	0.0
12.0	6.5	27.0	0.0
12.5	8.5	27.5	0.0
13.0	8.0	28.0	5.7
13.5	6.6	28.5	0.0
14.0	14.8	29.0	0.0
14.5	22.2	29.5	1.4

Long Beach Test No. 6 (11/7/74)

Traverse No. 1

Traverse on Highway 5 traveling South

Starting point: intersection of 5 and 605

Time: 10:54-11:14 a.m. (PST)

Miles from 5-605	$[SF_6]$, ppt	Miles from 5-605	$[SF_6]$, ppt
0.0	5.9	14.5	5.3
0.5	6.4	15.0	4.1
1.0	10.5	15.5	2.6
1.5	11.2	16.0	2.1
2.0	4.0	16.5	5.5
2.5	10.3	17.0	2.1
3.0	14.3		
3.5	12.5		
4.0	9.3		
4.5	8.4		
5.0	11.1		
5.5	12.1		
6.0	6.1		
6.5	6.1		
7.0	7.1		
7.5	4.6		
8.0	2.8		
8.5	0.0		
9.0	0.0		
9.5	0.0		
10.0	0.0		
10.5	0.0		
11.0	2.1		
11.5	0.0		
12.0	0.0		
12.5	4.1		
13.0	0.0		
13.5	0.0		
14.0	0.0		

Long Beach Test No. 6 (11/7/74)

Traverse No. 2

Traverse on Highway 5 traveling North

Starting point: intersection of 5 and 22

Time: 11:51 a.m. - 12:10 p.m. (PST)

Miles from 5-22	$[SF_6]$, ppt	Miles from 5-22	$[SF_6]$, ppt
0.0	1.8	14.5	4.7
0.5	1.5	15.0	6.7
1.0	0.0	15.5	4.2
1.5	0.0	16.0	5.7
2.0	3.3	16.5	7.5
2.5	0.0	17.0	7.1
3.0	1.8		
3.5	0.0		
4.0	0.0		
4.5	0.0		
5.0	0.0		
5.5	0.0		
6.0	0.0		
6.5	0.0		
7.0	1.0		
7.5	2.3		
8.0	2.1		
8.5	0.0		
9.0	2.0		
9.5	3.2		
10.0	2.1		
10.5	9.8		
11.0	5.7		
11.5	3.2		
12.0	1.1		
12.5	4.0		
13.0	5.7		
13.5	2.2		
14.0	2.7		

Long Beach Test No. 6 (11/7/74)

Traverse No. 3

Traverse on Highway 5 traveling South

Starting point: intersection of 5 and Imperial Highway

Time: 12:50-1:08 p.m. (PST)

Miles from 5-Imp.	[SF_6], ppt
0.0	3.0
0.5	4.1
1.0	0.0
1.5	1.8
2.0	0.0
2.5	1.3
3.0	0.0
3.5	1.9
4.0	2.3
4.5	2.5
5.0	1.3
5.5	1.4
6.0	2.1
6.5	3.2
7.0	0.0
7.5	2.5
8.0	2.1
8.5	0.0
9.0	0.0
9.5	0.0
10.0	0.0
10.5	1.1
11.0	2.9
11.5	0.0
12.0	2.0
12.5	4.6
13.0	5.8
13.5	3.9
14.0	0.0
14.5	17.6
15.0	0.0

Long Beach Test No. 6 (11/7/74)
Traverse No. 4
Traverse on Highway 5 traveling North
Starting point: intersection of 5 and 22
Time: 2:24-2:45 p.m. (PST)

Miles from 5-22	$[SF_6]$, ppt	Miles from 5-22	$[SF_6]$, ppt
0.0	1.0	14.5	2.7
0.5	0.0	15.0	2.4
1.0	0.0	15.5	1.7
1.5	0.0	16.0	2.2
2.0	0.0	16.5	5.1
2.5	0.0	17.0	1.7
3.0	2.2		
3.5	0.0		
4.0	2.8		
4.5	1.1		
5.0	6.8		
5.5	8.8		
6.0	33.0		
6.5	191.0		
7.0	146.0		
7.5	233.0		
8.0	177.0		
8.5	92.3		
9.0	12.6		
9.5	0.0		
10.0	0.0		
10.5	2.2		
11.0	0.0		
11.5	0.0		
12.0	0.0		
12.5	2.6		
13.0	2.1		
13.5	0.0		
14.0	0.0		

Long Beach Test No. 6 (11/7/74)

Traverse No. 5

Traverse on Highway 5 traveling South

Starting point: intersection of 5 and 605

Time: 2:53-3:11 p.m. (PST)

Miles from 5-605	$[SF_6]$, ppt	Miles from 5-605	$[SF_6]$, ppt
0.5	10.6	15.0	0.0
1.0	3.4	15.5	0.0
1.5	0.0	16.0	0.0
2.0	0.0	16.5	0.0
2.5	2.4	17.0	0.0
3.0	2.5	17.5	2.0
3.5	1.3		
4.0	0.0		
4.5	1.5		
5.0	1.4		
5.5	2.0		
6.0	1.6		
6.5	4.2		
7.0	3.4		
7.5	0.0		
8.0	0.0		
8.5	200.0		
9.0	172.0		
9.5	42.3		
10.0	0.0		
10.5	0.0		
11.0	0.0		
11.5	1.4		
12.0	0.0		
12.5	1.3		
13.0	0.0		
13.5	0.0		
14.0	0.0		
14.5	0.0		

Long Beach Test No. 6 (11/7/74)
Traverse No. 6
Traverse on Highway 5 heading North
Starting point: intersection of 5 and 22
Time: 3:50-4:10 p.m. (PST)

Miles from 5-22	$[SF_6]$, ppt	Miles from 5-22	$[SF_6]$, ppt
0.0	2.0	14.5	0.0
0.5	0.0	15.0	3.3
1.0	1.2	15.5	0.0
1.5	0.0	16.0	3.7
2.0	2.0	16.5	2.8
2.5	0.0	17.0	0.0
3.0	0.0		
3.5	0.0		
4.0	11.2		
4.5	24.8		
5.0	116.0		
5.5	83.1		
6.0	2.1		
6.5	1.6		
7.0	4.2		
7.5	0.0		
8.0	2.1		
8.5	0.0		
9.0	2.9		
9.5	3.9		
10.0	2.6		
10.5	4.8		
11.0	3.1		
11.5	0.0		
12.0	2.3		
12.5	2.4		
13.0	4.1		
13.5	0.0		
14.0	1.8		

Long Beach Test No. 6 (11/7/74)

Traverse No. 7

Traverse on Highway 405 heading East

Starting point: intersection of 405 and 19

Time: 2:03-2:15 p.m. (PST)

Miles from 405-19	[SF_6], ppt
0.0	0.0
0.5	0.0
1.0	3.4
1.5	1.5
2.0	0.0
2.5	0.0
3.0	0.0
3.5	7.1
4.0	0.0
4.5	0.0
5.0	0.0
5.5	0.0
6.0	0.0
6.5	1.2
7.0	0.0
7.5	0.0
8.0	0.0
8.5	0.0
9.0	0.0
9.5	0.0

APPENDIX A-9

Discussion of Anomalous Data Points

1. Location No. 19 - Long Beach Test No. 2

Relatively high SF_6 values were recorded at Location No. 19 (Corona) during the entire sampling period (8 a.m. - 8 p.m.) on 10/11/74. These points are probably due to a source of local contamination because:

(a) High concentrations were recorded between the hours of 8 - 10 a.m., before any tracer was released.

(b) The other four sampling locations in the Santa Ana Canyon (Locations No. 9, 14, 20, and 21) which surround Location 19 recorded very low tracer concentrations.

(c) The Rockwell SO_2 monitoring station at Location No. 19, although having recorder problems, did not show any significant SO_2 concentrations.

The anomalous data from Location No. 19 on Long Beach Test No. 2 are listed below:

Time of Day (PST)	SF_6, ppt
8-9 am	30.8
9-10 am	48.9
10-11 am	41.1
11-12 am	47.6
12-1 pm	83.5
1-2 pm	85.0
2-3 pm	109.0
3-4 pm	99.7
4-5 pm	108.0

5-6 pm	95.5
6-7 pm	5.3
7-8 pm	61.2

2. Locations No. 2 and 3 - Long Beach Test No. 6

Extremely high SF_6 concentrations were recorded during separate one-hour periods at Location No. 2 (Anaheim) and Location No. 3 (Garden Grove) on 11/7/74. These two points are probably due to a source of local contamination because:

(a) The two points are quite singular, having essentially zero concentration before and after them. The typical tracer data show a gradual peak over a number of hours.

(b) The Rockwell SO_2 monitoring stations at the above two locations did not show any significant SO_2 concentrations during the times of interest.

(c) Ground-level traverses made during the times of interest did not show any significant tracer concentrations (see Appendix A-8).

(d) Location No. 4, located only one-half mile from Location No. 2, did not show any significant tracer concentration during the hour of interest.

The two anomalous data points on Long Beach Test No. 6 are listed below:

Location No. 2	11-12 am (PST)	760 ppt SF_6
Location No. 3	1-2 pm (PST)	739 ppt SF_6

3. Anomalous Airborne SF_6 Data Points

In general, the airborne tracer data and the MRI SO_2 and NO_X data correlated very well. Three data points, however, did not correlate with the MRI measurements. These three anomalous data points are listed below:

(a) <u>High SF_6 points not supported by MRI measurements</u>

Long Beach Test No. 4	D to C	1300 ft.	485 ppt SF_6
Long Beach Test No. 6	D to E	1600 ft.	583 ppt SF_6

(b) <u>Lower SF_6 point than expected from MRI measurements</u>

Long Beach Test No. 5	E to F	1000 ft.	10.7 ppt SF_6

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Table D-2 (cont.)

Date	Basin	Base	Aircraft	Route	Time (PDT)	Comments
9/29/73	L. A.	Cable	205	South	0815-1022	Metronics tracer study day
				North	1200-1350	
				Riverside	1557-1750	
			310	North	0809-0943	
				South	1149-1329	
				North	1558-1720	
			Navy van shut down by 1800			
10/3/73	L. A.		Navy van operating by 1821			
		Cable	205	Special	0908-1103	
				Special	1453-1634	
			310	Special	0904-1122	Special flight
				Special	1456-1713	Upland-Freeway study
10/5/73	L. A.	Cable	205	Riverside	0825-1030	
				Riverside	1311-1438	
				Riverside	1707-1812	
			310	Special	1300-1415	Modified
				South	1619-1755	
			Navy van off by 1800			
11/6/73	L. A.		205	Special	1125-1225 PST	Freeway route
				Special	1401-1451 PST	Freeway route
				Special	1602-1646 PST	Freeway Route
1/9/74	Salinas	Salinas	205	Moss Landing Plume	1550-1740	Moss Landing Plume Study
1/10/74	Salinas	Salinas	205	Moss Landing Plume	0950-1150	
				Moss Landing Plume	1355-1545	